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Työn nimi Fabricated Tectonics: Two Shared Concepts in Architecture and Textile		
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What will be studied in this thesis are two concepts shared by architecture and textile. The first area studies the tension between ornament and structure and how this appears on both the facade design of buildings as well as in textiles. The second concept relates to the 'dressing' of structures, which examines structure systems as a whole in textile and architecture. The principles discussed are abstract, but can be applied within existing architectural and textile practices.

The body of work is generated by artistic and research based methods. Once the research question was decided, the problem began to be processed by drawing and weaving prototypes. In addition to this, it was necessary to contextualize the thesis question by researching within the field of architecture. The research provided a historical and theoretical base, which supplemented the artistic production. Both methods were used equally and simultaneously throughout the thesis.

This thesis seeks a new outlook on existing dilemmas within the practices of architecture and textile. Current developments in material usage and representation on building facades have raised the question of architectural ornamentation again. The two concepts are looked at within a historical context, revealing these issues to be persistent and universal by nature.

Consisting of two clear parts, the thesis has been divided into two separate books. The first part, which contains text supplemented by pictures, examines theoretical debates by architects and theorists. The theories are relevant to the topic and are illustrated by examples of architecture and textile. Even though the theoretical debates focus on architectural development, they are applicable within the context of textile also.

The second book catalogues the content of the exhibition in pictures and text. Examples of woven textiles paired with architectural drawings contribute to the arguments presented by demonstrating these abstract concepts in a visible, concrete manner. These textiles and drawings represent both the byproduct of the research process as well as the content of the final exhibition.

Avainsanat textile, architecture, tectonics, structure, ornament, weaving, curtain wall

Fabricated Tectonics

Two Shared Concepts in Architecture and Textile

Tiina Teräs / Masters Thesis

Masters Degree Program in Spatial Design / Department of Design, School of Arts, Design and Architecture / Aalto University

Part I

Theory

A warm thank you to everyone who offered their support and guidance during the making of this thesis.

Supervisors Maarit Salolainen and Pentti Kareoja
all teachers and tutors, studiomasters, coursemates, friends and family.

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1 Introduction and Framework for Thesis

1.1

Preface

This work covers two areas where architectural and textile structures converge. The principles discussed are abstract, but can be found in and applied within both practices on a tangible level. These theories describe certain qualities found in both architecture and textiles and how they are used.

Subject areas that will be looked at include ornamentation, the interrelatedness of material and structure and the concept of 'dressing' in architecture. Examples of woven textiles paired with architectural drawings will contribute to the arguments presented by demonstrating these abstract concepts in a visible, concrete manner.

1.2

Introduction

This thesis is the product of both artistic and research based methods. Once the research question was decided, the topic began to be processed by drawing and weaving prototypes. This constitutes the artistic production part. In addition to this, it was necessary to contextualize the thesis question by researching within the field of architecture. The research provided a historical and theoretical base, which supplemented the artistic production. Also, both artistic and research-based methods were used equally and simultaneously throughout the thesis.

1.2.1

Part I: Theory

The written part of this thesis will outline how some of the key concepts regarding structures within architecture also exist in textile. These concepts are mainly examined through architectural theories and design paradigms. Connections are drawn to corresponding examples of textile through pictures. By studying the overlapping areas between architecture and textile structures, it was possible to reveal certain universal principles among the two. These universal principles are discussed separately and in detail in the section preceding the catalogue of examples.

The use of sources in this thesis is divided into two parts. The first set of sources– or bibliography– is referenced actively in the text, but the common viewpoint forming the basis of the thesis is the result of a wider range of literature. This can be found in the section marked as the Additional Sources.

1.2.2

Part II: Application

The catalogue, which makes up a separate book, documents the content of the exhibition. This exhibition consists of six textile prototypes paired with architectural drawings. The textiles are loom woven apart from one, which is felted. Each textile prototype represents a different way to organize yarns and fibers to create fabric. As opposed to knitting, which consists of loops and meshes, weaving uses a system based on horizontal and vertical organization of material, bringing it close to architecture. The architectural images have been drawn using ink pen and are to scale. They illustrate common building practices that can be found in any larger urban area.

These textiles and drawings represent both the byproduct of the research process as well as the content of the final exhibition. The purpose of the exhibition is to bring architecture and textiles closer together for the viewer in light of the topics discussed in the theoretical part of the thesis. The illustrations and prototypes aim to demonstrate that textiles and architecture share common ground and these shared characteristics could be used to seek new approaches to problems related to ornamentation and structure.

1.3

Framework of thesis

1.3.1

Conceptual, not literal

When thinking about the links between architecture and textile, examples of buildings constructed from textiles may first spring to mind. Examples range from nomadic tents (see Fig.1) to the tensile and pneumatic structures of architect Frei Otto (see Fig.2). This use of textile is literal, direct and often highly technical. The forms of buildings incorporating textile are often clearly dictated by culture, climate or technology and have been studied to a large extent already. Excluding one theory that draws on the textile origins of architectural ornament and structure, this thesis is examining the more indirect, conceptual themes present in both textiles and buildings.

1.3.2

Ornament and structure

The subject of pure ornamentation in architecture and textiles will not be studied in detail in this work. Even though it is integral to the general topic and therefore cannot be avoided completely, this subject area alone would require a separate thesis. Studying the use of pattern and ornamentation in architecture and textile naturally turns to an ethnographical, even psychological point of view and the motives for using ornament in architecture can be as numerous as there are architects. This branch of investigation would therefore detract from the central argument, which centers on tectonics, or structure. On the other hand, applied ornamentation that is directly and consciously in dialogue with structure is relevant to the topic.

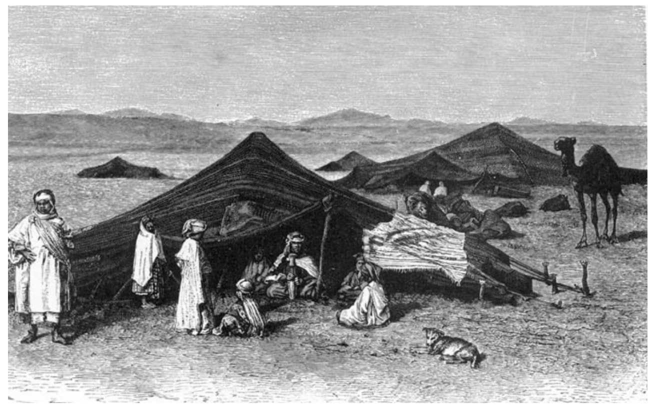
Fig.1


Fig.2

1.3.3

Visible aspects

It is clear that architecture and textile cannot only be defined by what is visible even if sight is the first sense employed upon encountering a building. The exterior is the first perceivable part and often contributes strongly to initial impressions, often flavoring the entire experience of a work of architecture or textile. Despite this inevitable condition, buildings and fabric are complex amalgamations of context, structure and use, including intangible aspects such as atmosphere and spatial experience. Their multifaceted nature is not forgotten in this thesis, but the discussion will center mainly on the issues related to the visible elements. Also, through the two-dimensional medium of drawing, it is possible to examine purely the tectonic aspects of architectural systems, presenting what is relevant to this thesis.

1.3.4

The envelope

The exterior envelope of architecture will be the starting point. There exist a number of widely known debates in architecture relating to façade design. For example, architects have battled with the concepts of ornament and pure function, striving to find the ideal balance between the two. Traditionally, the target of this debate has been the exterior of a building, but not exclusively. This same focus persists in textile, where the term surface design is used to describe properties such as color and pattern. Especially in printed textiles, the tendency is greater to direct the attention to superficial properties, sometimes forgetting that applying fields of color to a fabric adds three-dimensionality and changes the nature of the fibers therefore affecting the fabric on a structural level.

The use of the word envelope is appropriate when considering examples of contemporary architecture. In some buildings, very little distinction is made between the exterior elements of wall, floor and roof, which can be combined into one single membrane encircling the building.

In light of these considerations, it is not the intention to separate the interior from the exterior in this thesis. Although the focus will be initially directed at the exterior envelope of a building because changes in architectural ideology are most evident there, the work of architecture will be considered as a whole, much like a textile needs to be considered as a sum of its parts and not solely for the appearance of its surface.

1.3.5

The historical scope

Links made between architecture and textile is not a new development. Because of the surprising wealth of knowledge in this area, the route of exploration for this topic will be largely historical, looking at how this connection is evident in examples of architecture in the past two centuries. Theories on tectonics, or structure, emerged after the Enlightenment and began gaining popularity at the turn of the nineteenth century, their effects still apparent in architectural practices today.

From the start of this development to modernity, two different paths have formed, linking architecture to textiles. These two approaches have either directly shaped architectural structures and informed the use of materials or influenced the conceptual and physical organization of the building elements.

These theories and debates may not always follow a strict chronological order. Instead, they will be looked at in two groups, with each group representing an individual architectural concept with textile origins.

1.3.6

Terminology

Commonly used terms such as curtain wall, filigree construction, building envelope and fabrication all have roots in textile practices. Language effectively reveals a connection between built form and textile on a conceptual level. In this thesis, the definition of envelope refers to the floor, wall and roof elements as one component due to very little distinction made between the three in certain architectural styles. Additionally, the word filigree will be used, often in conjunction with the monolithic to describe two different structural systems in architecture. This pair of definitions is directly borrowed from the book Constructing Architecture (Deplazes et al. 2005) to describe the two different structural typologies.

2 Relationship of Ornament to Structure

2.1

Introduction

This first section will describe a quality intrinsic to both textile structures and architecture. In architecture, the classical debate on form and function has had a profound influence on numerous architects and theorists, who have often attempted to find a balance between the two. This issue is illustrated well in the complex relationship between ornament and structure, which is equally as common in the field of textile.

This dilemma of ornament versus structure is evidenced through the practice of facade design and surface design. There seems to exist a strong culture of hiding and exposure, where the object of exposure is usually an internal structure. What are the causes behind this phenomenon and in what ways is this manifested in both disciplines?

In this work this phenomenon is studied by following the development of the relationship between ornament and structure in architecture. This particular section follows this evolution, beginning with complete coverage and ending with complete exposure. A period of different approaches to integrate the two exists between these two extremes.

2.2

Coverage: The practice of ornamental incrustation

2.2.1

Architecture prior to Structural Rationalism

Architecture in Europe before the eighteenth century was based on imitation and strict paradigms of symmetry, proportion and harmony. During the Renaissance for example, architects sought inspiration within the framework of music and mathematics. Romanticizing antiquity was also common, with decorative elements from Ancient Greek, Roman and also Medieval Gothic styles sometimes all combined into a single edifice of a building.

(Fig.3)

Jacques-Germaine Soufflot, Compositional study of St. Genevieve (le Panthéon), Paris,

Stylistic borrowing was often direct. Architecture was commonly viewed as a single object, appraised for adhering to the above mentioned design principles of symmetry and proportion (see Fig.3). As a result, this particular viewpoint denigrated architecture to a lower realm of a hierarchy that existed in the fine arts before the Enlightenment.

What hindered architecture from becoming a 'pure art', was its mechanical nature and initial condition of necessity. Gradually, ornamental incrustation became more reduced in its aesthetic and the study of tectonics through Structural Rationalism could be seen as a response to this. (Schwarzer. 1993, 267-280.)

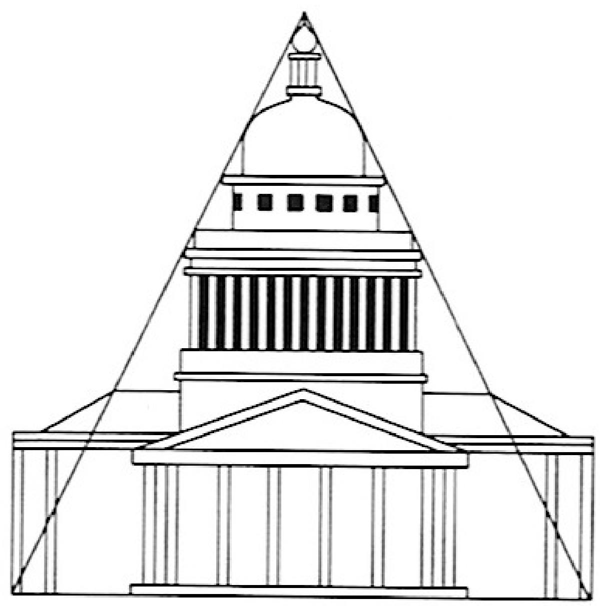

Fig.3

2.2.2

Structure and ornamental features are ideologically separated

Through the influence of Structural Rationalism, architects and architectural theorists began recognizing the discrepancy between applied surface ornament and the underlying structure supporting it. During this time, numerous writings began appearing on the subject of adorned architecture. Ornamental incrustation of the built surface was abhorred and praised alike, depending on what justification was provided for its use.

Many architects began considering structure as integral to the design of a building. Instead of covering the underlying surface completely, they began experimenting with ways to reveal the structure through the use of ornament. This period in time could be said to have marked a turning point in architectural thinking, having far-reaching consequences that are visible to this day.

(Fig.4)

Charterhouse, Granada, detail of sacristy

(Fig.5)

Giacomo della Porta, S. Caterina de' Fumari, facade, Rome

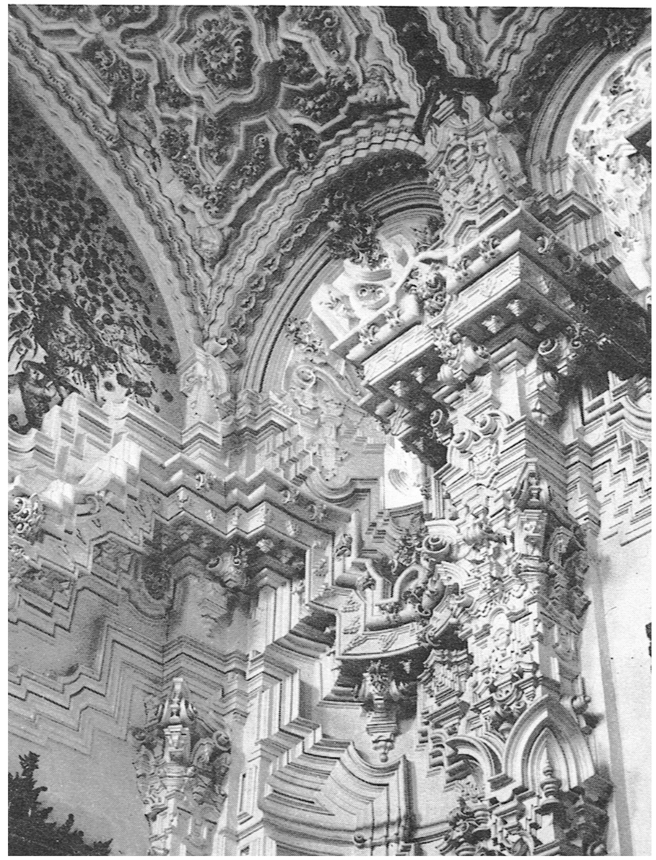

Fig.4

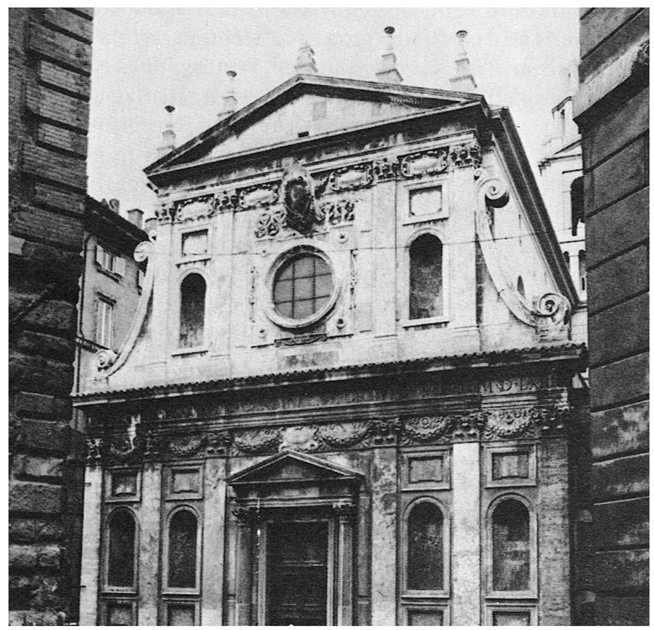

Fig.5

2.3

Striving for equilibrium

2.3.1

Rationalizing ornament

The German rationalist by the name of Karl Bötticher became one of the first to forge a rational link between ornament and structure through his theory on tectonics. Until this point, there had been little demand for rationalized ornament. He strove to find an alternative to architectural design that did not treat buildings as single objects governed by the formal factors of symmetry and proportion. Countering these Renaissance ideals, Bötticher studied techniques of construction and attempted to find a way to reveal this through ornamentation. (Schwarzer. 1993, 267-280.)

This new outlook was born from the appreciation of Ancient Greek architecture, which many architectural theorists held in high esteem at that time. Ornament's symbolic function on the edifices of Greek temples held special appeal for Bötticher. He also valued medieval, Gothic architecture for its integration of structure and ornament (see Fig.7). Based on these precedents and others, he devised a theory on tectonics. (ibid.)

In Greek and Gothic architecture, Bötticher noted that the placement and type of ornament illustrated tectonic roles and relationships between architectural elements such as column, roof and floor (see Fig.6). Based on these findings, Bötticher gave ornament a new informative purpose. A building's internal structural functions should be made visible on the exterior through ornamental symbols. This theory broke existing conventions regarding ornamentation by intrinsically linking a previously aesthetic-driven practice with function.

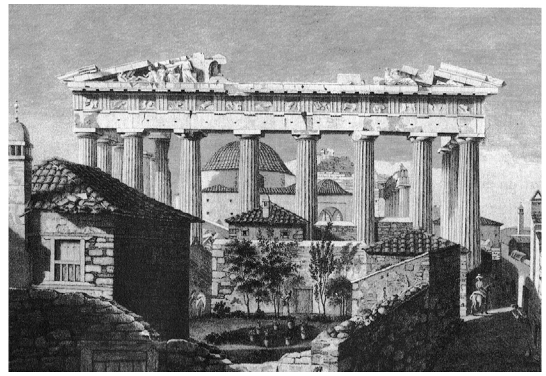

Fig.6

Fig.7

(Fig.6)

Drawing of the Parthenon, 1751

(Fig.7)

King's College Chapel, Cambridge, England, 1446-1515

2.3.2

Using ornament for representation

As a result of early rationalist theories such as Bötticher's, the wall's representational potential came under scrutiny. The wall was not seen as a blank canvas anymore, but integrated into a structural whole. An excellent examples of this can be found in Austria, where the Viennese Secessionist style emphasized the structure of buildings through ornamental additions to the façade.

The Secessionists aimed at creating a set of new design paradigms based on the conviction that every period should have its own form of artistic expression. Precedent was taken from English design, which was viewed as sophisticated and 'clear'. The new style of ornament was based largely on graphic, geometrical forms and has been interpreted to be a reaction against the more ornate and vernacular Jugendstil in Germany at the time (Benton, Muthesius, Wilkins, 1975, 20-21.)

These ideas regarding ornamentation became visible at an early stage in the architecture of Vienna. A proponent of Secessionist and also modernist architecture was Otto Wagner. He was one of the first to assert this new design paradigm, having a major influence on the following generation of Secessionist architects.

In his design for the Postsparkasse building in Vienna, the use of cladding material reveals a new, more structural approach to facade design (see Fig.8). Wagner's architectural work will be looked at more closely in the next chapter.

Fig.8

(Fig.8)

Otto Wagner, Postsparkassenamt, Vienna. The exterior masonry has a tile-like, lightweight appearance.

The architect that most visibly embraced the concept of using ornament to emphasize structure was Joseph Hoffmann. He belonged to the group of architects that placed great emphasis on façade design, considering aspects such as composition, linearity and material juxtapositions. Hoffmann became a master in ornamentation, applying bold ornament to accentuate the forms of the building. (Benton, Muthesius, Wilkins, 1975, 25.)

The dialogue between ornamentation and structure is exemplified in the Palais Stoclet in Vienna (see Fig.9). Built in 1905, it represents a more mature era of Hoffmann's work, where the cornerstones of the Secessionist style are clearly visible. Pure, geometrical forms are employed on the exterior in a way that emphasizes the high-quality materials. As a result of reduced ornament, the functional parts of the building are given new visual significance. Openings on the exterior are clearly articulated and carefully placed, transferred from pure function to the role of ornament.

The exterior walls of the Palais Stoclet are made from white Norwegian marble and the linear ornamental moldings are made from metal. The contrasting materials became the defining optical feature of the building. The placement of the metal moldings emphasizes the massing of the building by separating the exterior walls into single components. (Benton, Muthesius, Wilkins, 1975, 35-36.)

At this point, this particular style of ornamentation discarded antiquated notions of superficial decorum, favoring more modern ideals of honesty in both structure and material. Applied ornament has become responsive to what lies underneath.

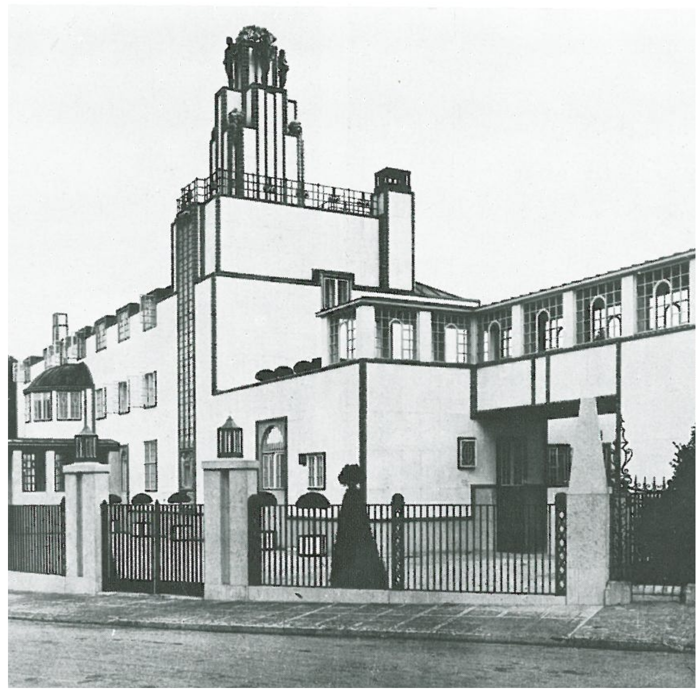

Fig.9

(Fig.9)

Joseph Hoffmann, Palais Stoclet, Vienna

2.4

Exposure: the ontology of ornament changes

2.4.1

Material as ornament

Hoffmann placed great emphasis on materials such as metal and glass, but his contemporary Adolf Loos implemented this approach to a greater extent. Loos became known for his vehement support for material honesty, which he advocated in his written work *Ornament and Crime* as well as in his architectural commissions. Branching out from original rationalist theory, Loos supported the use of high quality materials in a way that emphasized their intrinsic characteristics. In his view, true ornament was derived from the structural and surface characteristics of a raw material.

(Fig.10)
Adolf Loos, marble lacunar ceiling in the Kärntner Bar, Vienna
(Fig.11)
Adolf Loos, interior of apartment for W illy Kraus. Polished marble, glass and dark wood in the dining room.

Fig.10

Fig.11

Loos produced a noticeable body or work during his time, but one of his most well known buildings is the Müller House. It is also seen as his last significant work, embodying the design paradigms most central to his career. The most striking feature of this commission is the design of the exterior envelope (see Fig.12) and the materials chosen for the interior (see Fig.13).

Much like his rationalist predecessors, Loos used materials in an ornamental-symbolic way to signify the function of the rooms in the Müller House. Materials such as wood and marble were employed in the interiors and treated in a way that emphasized natural patterns produced by the material. The veins in marble become more visible upon polishing and the natural grain of wood becomes decorative when glazed. Loos uses these materials in a manner that psychologically and functionally differentiates each room in the house. In contrast to the the rich interiors, the exterior of the Müller House was left minimalistic and functional. (Gravagnuolo, 1982, 201-203.)

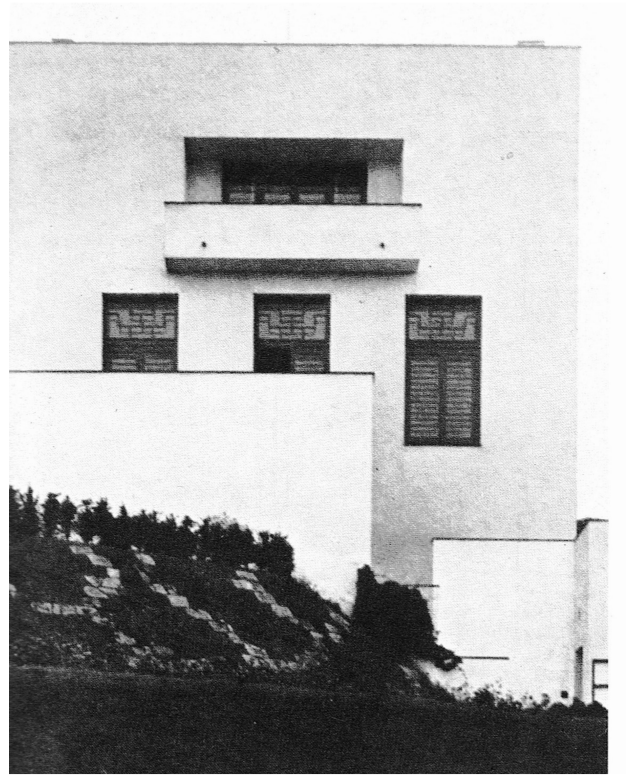

Fig.12

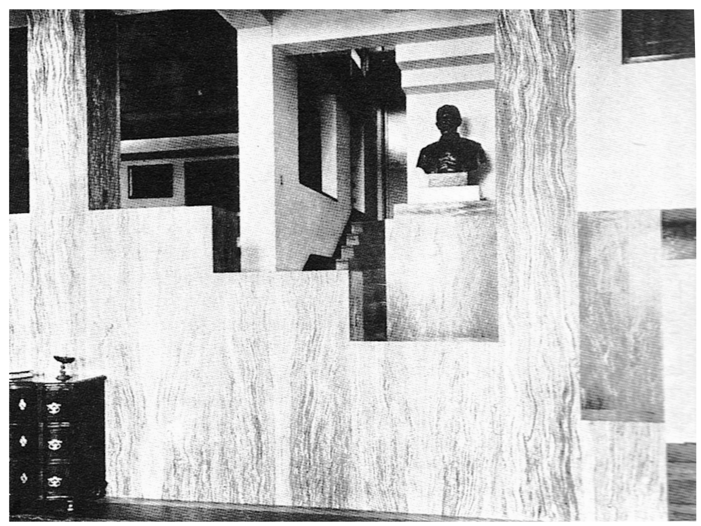

Fig.13

(Fig.12)
Adolf Loos, exterior facade of the Müller House, Vienna
(Fig.13)
Adolf Loos, marble staircase in the Müller House, Vienna

2.4.2

Structure as ornament

This next example marks one of the more drastic changes in ornament's ontological identity. So far, the previous examples have outlined ornament's role in emphasizing structure and how a material's intrinsic properties can be seen as ornamental. The role of ornament has become increasingly abstracted along the way and reaches a peak of abstraction through certain technical developments during twentieth century.

As the debate on architectural adornment progressed, simultaneous developments in material technology made it possible to realize radical new concepts. For instance, the introduction of concrete, glass and steel to the building industry brought about new, more structurally integrated building systems. The turn of the century was a time of experimentation with minimum material and maximum span, where the professional roles of architect and engineer became blurred. Light, transparent and transitory structures became prevalent and came to represent progress.

Due to changes in materials and systems used to construct architecture, it was necessary for architects to reconsider the necessity of architectural ornament in any form. One of the most iconic and pioneering buildings representing the ideals of its time was Joseph Paxton's Crystal Palace (see Fig.14). An excellent example of embracing technological advancements, the structure consisted of 93,000 square meters of steel frame with glass infill panels. (Frampton, 1992, 34-35).

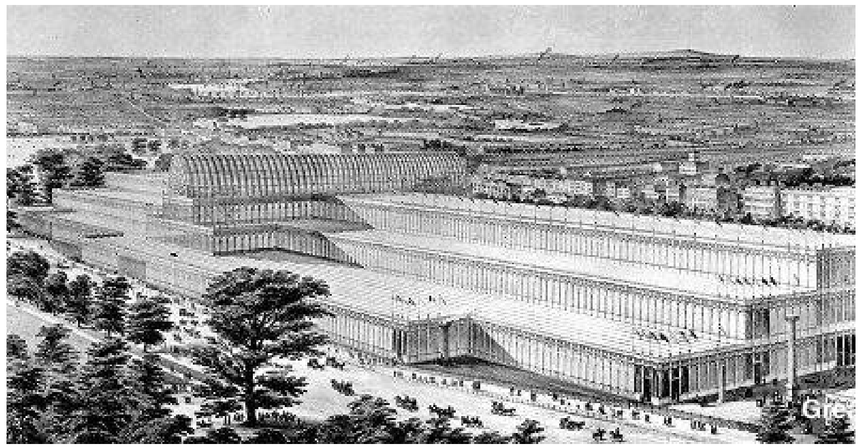

Fig.14

(Fig.14)

Joseph Paxton, The Crystal Palace, aerial view

The two materials of glass and steel support each other as a single structure, merging into one component instead of remaining as separate components functioning on different levels. Taking for instance earlier composite structures such as timber frame and infill systems, the frame serves as the structural component and the infill purely as cladding. The integration of steel with glass infill panels obscured the previously clear, layered boundaries between structure and cladding, eventually challenging the necessity of applied architectural ornament altogether. (Frampton, 1992, 34-35.)

What was significant about this development was the distinct aesthetic that resulted from exposed materials and articulated structures. The properties of cast iron or steel lattices, such as their lightweight and transparency, were still used to create solely ornamental architecture at this time, but ornament had moved already closer to structure at this point. With Paxton's Crystal Palace representing one extreme, the architecture of this period was exceptionally varied, existing at a crux between visual expression and tectonic truthfulness.

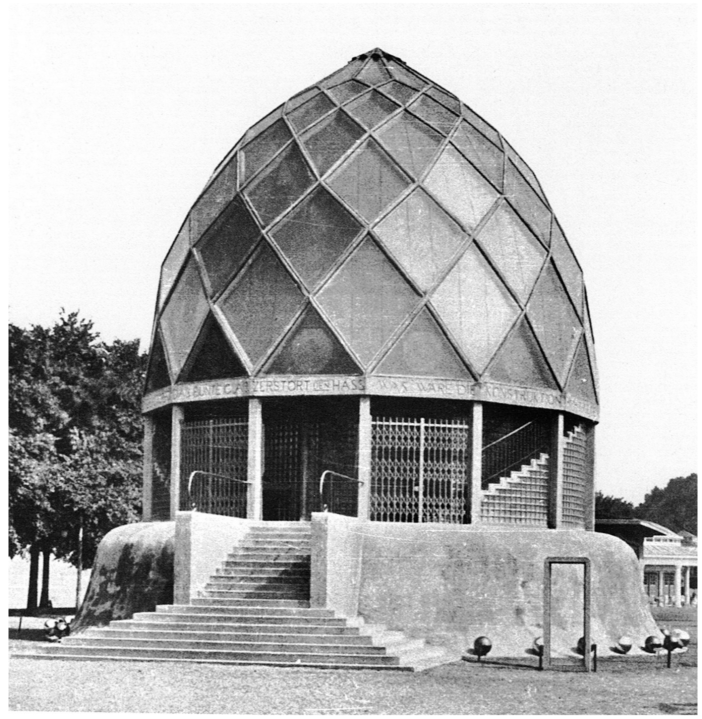

Fig.15

(Fig.15).

A new, lighter architecture. Bruno Taut's "Spargelkopf" pavilion, 1914. Lattice structure of glass and steel make up the dome.

3 Relationship of Parts to a Whole

3.1

Introduction

The following section examines the notion of ‘dressing’ in architecture. This word implies covering or veiling what is behind, usually with another material. Examples in this section will illustrate the dressing of buildings conceptually as well as physically. Beginning with a theory based on the use of textile to define space in primitive dwellings, the presence of this textile aspect is followed through examples of architecture.

The element that most clearly conveys the role of dressing within architecture is the wall. The focus will be on the wall as a single unit and its relationship to the structure underneath. How do the elements of facade and structure work as an integrated system and how is this same system seen in textile practices? A theory making an analogy between the clothed body and architecture will be studied in response to this.

3.2

The wall and frame

The tectonic relationship between the internal structure and external cladding will be examined as an organizational principle in architecture. The very essence of this textile property of 'dressing' or covering a stiff structure with another material is not exclusive to architecture though. It is also intrinsic to fashion. Concepts present in fashion are also found in architecture, such as the question of style. For instance, the turn of the twentieth century saw dramatic changes in architecture and fashion and for a time these two were examined as equals. Following the notion of 'decorum', where the social status of an individual could be read from their dress, architectural façades were understood to serve the same purpose as human dress, therefore making built form open to the same issues as fashion.

From the concept of draping and dressing arises a new treatment of the architectural façade. Still moving within the realm of hard materials, the external cladding element is removed from the internal frame allowing for a new freedom in façade design. The supporting structure can now be found at the center of the building. Again, similar to Renaissance buildings, the internal structure is hidden, only now even deeper, within the core of the building.

It could be argued that this concept of an outer veil applied to an inner structure was also the result of the Structural Rationalism movement, initiated in Europe by theorists such as Karl Bötticher Eugéne Viollet-le-Duc and Gottfried Semper. The Structural Rationalists' approach to breaking down the architectural mass into clear elements such as frame and cladding, gave rise to a new type of analogy between architecture and textile.

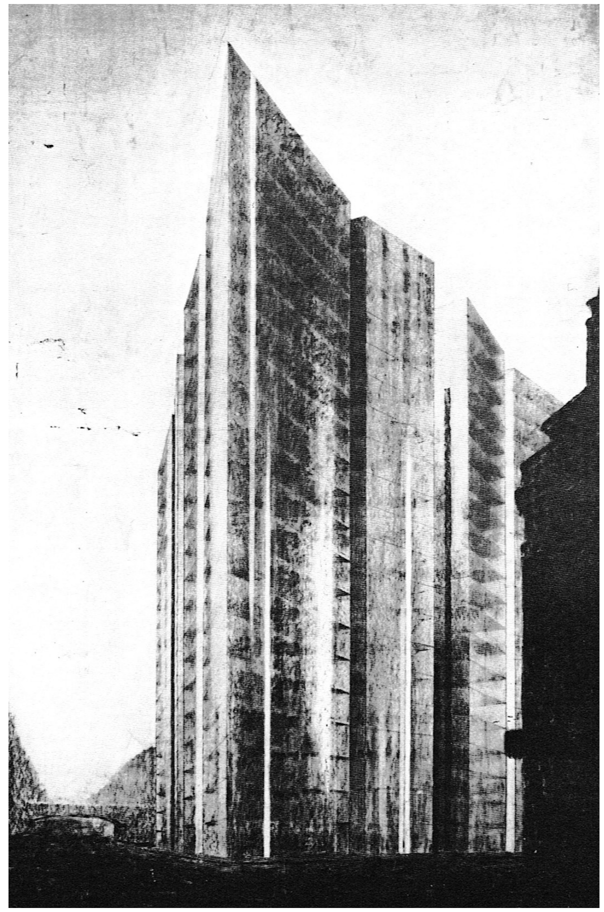

Fig.16

(Fig.16)

First scheme for office building project, Mies van der Rohe, Friedrichstrasse, Berlin

3.2.1

The textile origins of an architectural system

The analogy of dressing in architecture accurately illustrates the tectonic relationship between the two architectural elements of load-bearing structure and external cladding. Recognizing this tendency to 'clothe' structures, the architectural theorist Gottfried Semper (1803-1879) formulated a theory on the textile origins of architectural structure and ornament.

Semper worked mainly in Germany at the turn of the twentieth century and became widely influential in Europe. Like many of his contemporaries, he was concerned with finding the origin of architecture. At that particular time, it was customary to study primitive and ancient building practices in an attempt to discover architecture's essence (see Fig.17 and Fig.18).

Semper suggested that the first building was in fact a filigree construction, instead of monolithic. Initially formed of reed mats and later substituted with carpets, this dwelling was called the Caribbean hut, denoting the location of the first discoveries (see Fig.20).

In order to hold the mats and carpets in place, a rigid frame was required, the earliest examples being made of timber. The use of this frame and infill system was not conscious though. According to Semper, the notion of structures to hold partitions was foreign to primitive architectural thinking and was not initially used as a form-determining element. It was the textile panels that created both interior enclosure and external visual appeal. (Houze 2006, 295.)

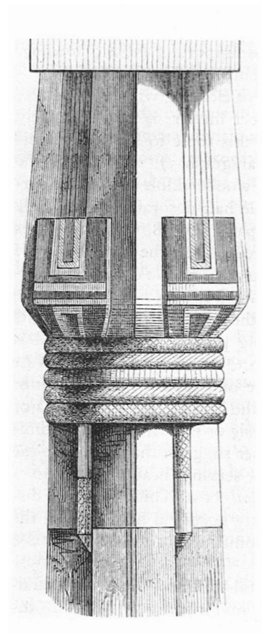

Fig.17

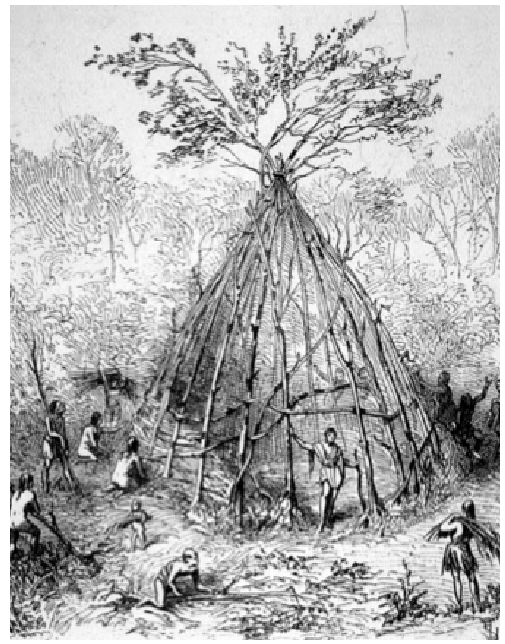

Fig.18

(Fig.17)

Study of Egyptian capital, Semper

(Fig.18)

The Primitive Hut, Viollet-le-Duc

This tectonic relationship was viewed as a pre architectural condition, eventually evolving into solid masonry walls. Although the masonry would have been enough to constitute a wall on its own, controversially Semper stressed that the function of these walls was still not spatial; they existed only to provide a better frame for the textile screens. The walls were in fact often hidden underneath the textile completely, giving them the passive role of an invisible structure. This suggested that the woven surface was the true representative of the wall. (Semper 1989, 255).

According to Semper, all built form came from textile production methods. The knot was the first architectural joint (see Fig.19) and architectural motifs are anthropological by origin, being derived from a culture's applied arts.

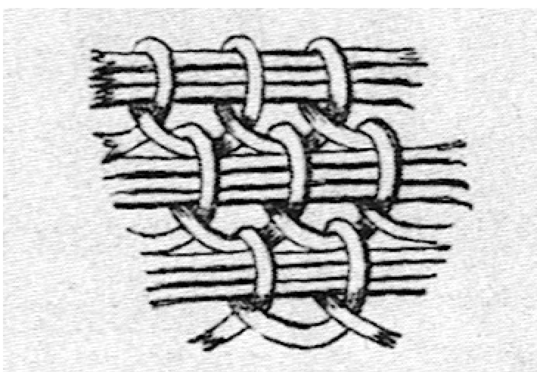

Fig.19

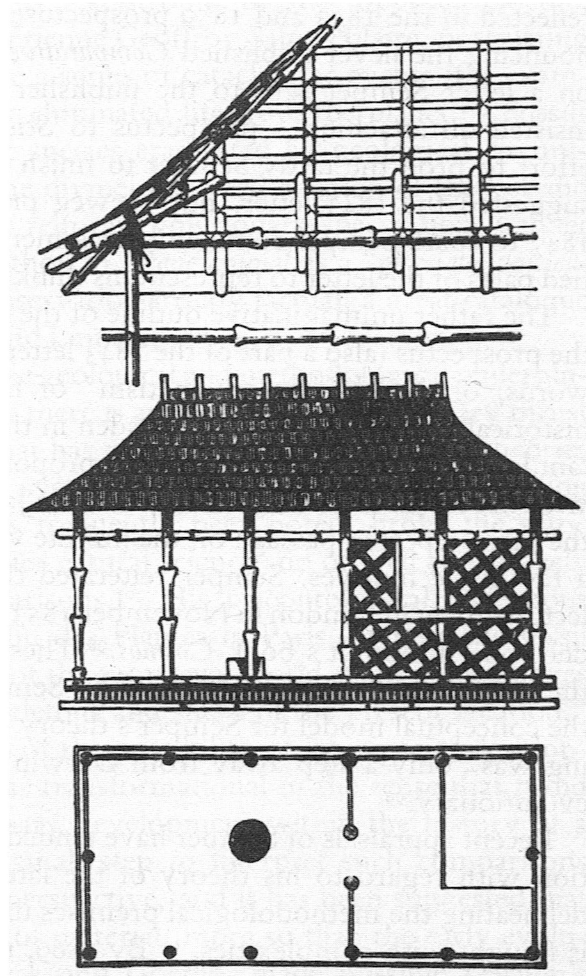

Fig.20

(Fig.19)

Guipure lacework, the oldest form of lacework

(Fig.20)

Semper's Caribbean Hut. Plan , elevation and section of roof

(Fig.21)

Lycian tombs, previously constructed out of wooden frames and carpets and later transposed into stone.

As material culture developed, more hardwearing materials such as stucco, terracotta and metal replaced textiles and hanging artifacts. Interestingly, at this junction, the materials had changed, but the motifs found in the initial textile surfaces remained the same (see Fig.21). Semper had successfully traced the beginning of architectural ornamentation and structural elements to culturally specific textile practices. (Semper 1989, 255).

This forms the basis of Semper's theory of *Bekleidung* or dressing, which posits that architectural enclosures are an extension of the fabric worn by the people. Screen-like walls in permanent architecture are reminiscent of the textile forms of nomadic tents and terracotta facing and brickwork were also the tectonic transpositions of woven textile.

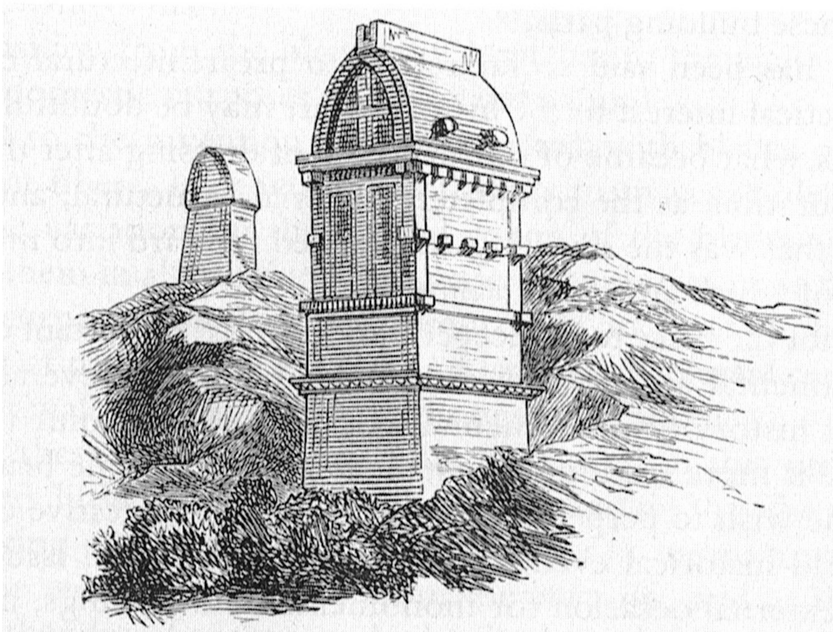

Fig.21

3.3

Conceptual separation of wall and frame

In order to achieve the state of physical separation, the two elements of wall and frame were first conceptually detached from one another. Conceptual separation in this instance meant that the two elements are treated as separate from each other even though they aren't physically standing apart.

Among other late nineteenth century architects, Otto Wagner was one architect influenced by Semper's work on the textile origins of architecture. Much like the pre architectural frame and textile constructions, the structure and the façade veil are constantly in dialogue with each other in many examples of Wagner's work. In the design of the Budapest synagogue for instance, Wagner concreticizes the principles of material transformation originally put forth by Semper in his theory of *Bekleidung*.

Otto Wagner's Budapest synagogue is clad in blue and orange glazed tiles. 'Here Wagner's building alludes deliberately to Semper's theory of the symbolic transformation of motifs from one material to another.' (Houze 2006, 295.) Despite using a non textile material such as ceramic tiles to clad the structure of the synagogue, this material is employed in a textile-like way by physically covering the structure and making visual references to fabric types such as printed and woven cloth. The original connection between hard materials and textile was made by Semper, who suggested they began to be manufactured like textiles, only on an architectural scale. In this example, Wagner engages with Semper's theory on architecture through his treatment of the façade using ceramics. (Houze 2006, 297).

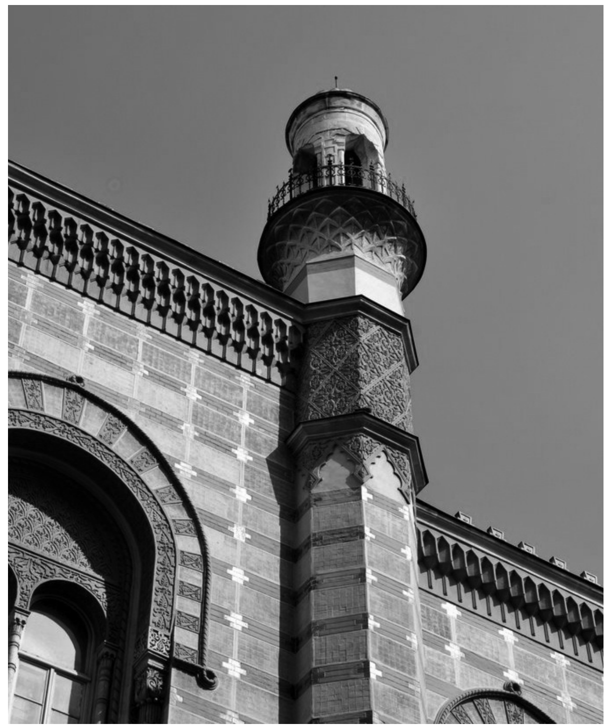

Fig.22

(Fig.22)

Part of façade, Budapest Synagogue, Otto Wagner

3.3.1

Analogies with the body

The writings of Victorian art critic and theorist John Ruskin reveal another, distinct point of view on the commonalities between architecture and textile. Like Semper, Ruskin detected a close link between architecture and clothing, giving particular meaning to the façades of buildings. He also emphasized the role that construction materials play in determining the final form of a building.

According to Ruskin, the soul of the wearer is revealed in their clothing much as the soul of the building is revealed in its exterior walls. Secondly, Ruskin detected similarities in composition between the decorative veneer of façades and clothing, again following the same path as Semper's argument on ornamentation.

Ruskin's invention of the term *wall veil* in his theory on architecture, reveals his view of buildings to follow similar principles to textile as whole systems. It describes the conceptual relationship between cladding and structure in a building. The term veil itself draws a connection to clothing and fabric. Whereas Semper looked purely at the evolution of ornamentation in dress and architecture in his theory of material transformation, Ruskin derived his theory from the body's relation to clothing and applied it to architecture. Just as the skin and fabric act as enclosing membranes for the body, walls of a building keep the essential interior components safe from the outside. (Chatterjee 2009, 68-97.)

Ruskin concentrated more on the wall veil's function as part of a whole rather than its method of production. To Ruskin, the wall veil was the key element defining architecture. This viewpoint could be said to predate the modernist concept and structural system of the curtain wall.

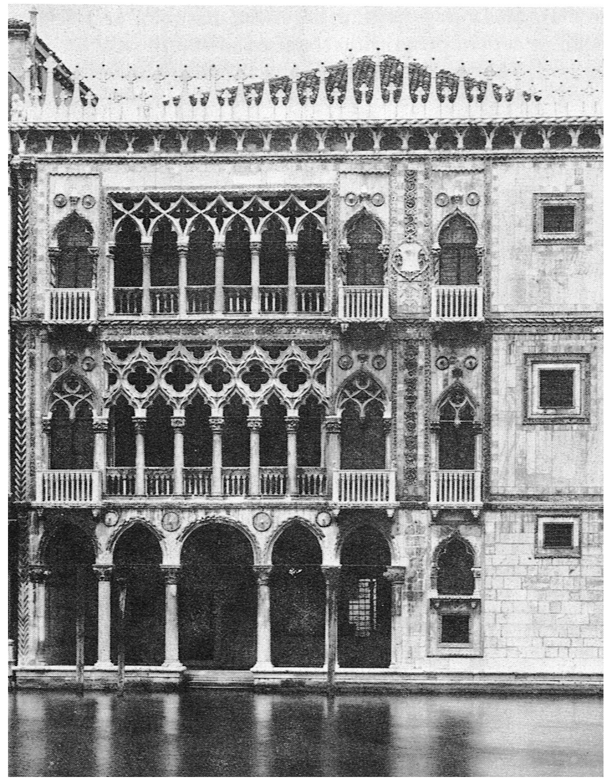

Fig.23

(Fig.23)

Ruskin studied the significance of façade ornamentation on Venetian Gothic buildings. Ca d' Oro, Venice

The analogy between the architectural wall and clothing could also be seen in intense debates on style that took place in central Europe around the turn of the twentieth century. This trend was particularly noticeable in Vienna, a metropolis that was experiencing a broad cultural transformation at this time.

Architects such as Adolf Loos and Joseph Hoffmann, applied Semper's *Bekledungsprinzip* on a more conceptual level by emphasizing the role of textiles in interiors and using textile-like elements such as screen walls and painted motifs. The architects would employ drapery, carpets and upholstery to 'dress' spaces. This resonated with Semper's theory on the first architectural structures being created to support textile elements on the interior.

Both architects were inspired by the same theory, but due to their opposing opinions on dress and fashion, their works of architecture resembled stylistic opposites. In fashion and architectural style, Loos looked to minimalist and sometimes masculine forms, often found in American and English fashions. Joseph Hoffman on the other hand was driven to explore new forms, colors and patterns, developing a more feminine, decorative style. Being contemporaries, both architects acknowledged the other's presence, but could not work together for their views on style differed too drastically.

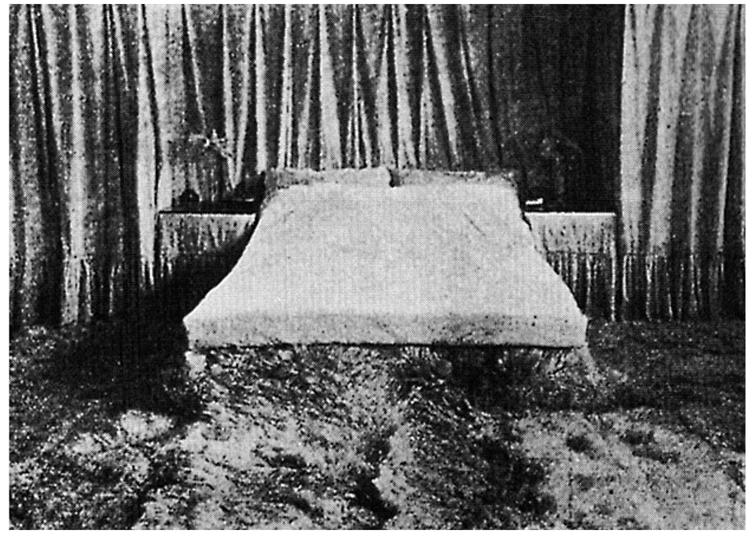

Fig.24

Fig.25

(Fig.24)

Interior of bedroom for wife Lina Loos, Adolf Loos

(Fig.25)

Great Hall interior, Palais Stoclet, Joseph Hoffmann

Fig.26

Fig.27

(Fig.27)

The flaring hem and chrysanthemum pattern along with the lacy gigot sleeves and a tight bodice emphasize feminine features. Example of women's evening fashion in France, circa 1900

(Fig.26)

The tailored jacket and jodhpurs reference men's style and the skirt is muted in silhouette and color. A British women's riding costume, circa 1900

3.4

The physical separation of wall and frame

By the advent of modernism, the concept of dressing referred clearly to the physical separation of the load bearing structure of a building and its external cladding. By removing the structural function of the external wall to an internal core, architects were able to physically drape or veil a thin layer or glass or other material around the primary structure.

At this point, the concept of dressing has transformed into a physical act, turning an analogy into reality. Despite having its ideological beginnings long before twentieth century modernism, this organizational concept was termed the curtain wall after the iconic pavilions and skyscrapers of Mies van der Rohe. This particular term embodies a textile system in architecture on a semantic and conceptual level.

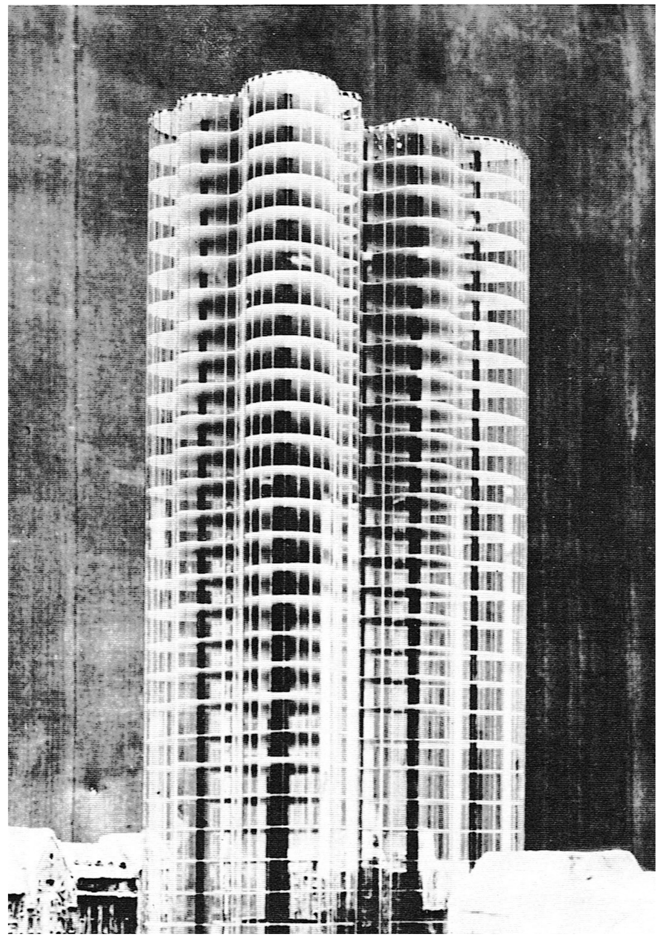

Fig.28

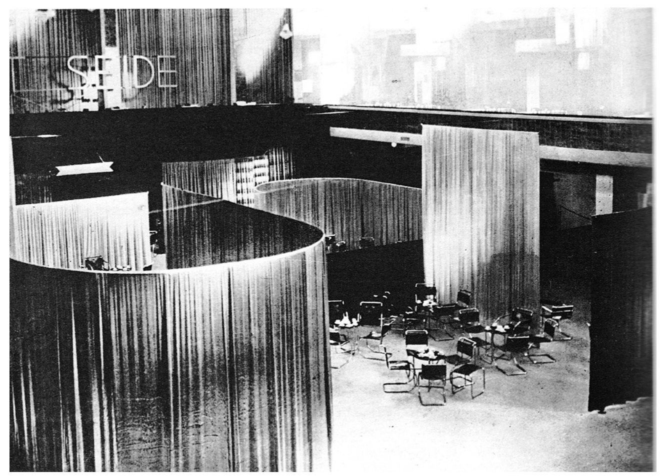

Fig.29

(Fig.28)

Mies van der Rohe, Model of glass skyscraper project

(Fig.29)

The curtain wall applied on the interior as space dividers. Mies van der Rohe, Silk Exhibit, , Berlin 1927

3.4.1

The original curtain wall

Mies van der Rohe has been said to pioneer the concept of the curtain wall, crystallizing the work of numerous architects for the past two centuries. In his buildings, the textile-like property of the wall is more literal than his predecessors such as John Ruskin or Otto Wagner. Instead of just creating the illusion of a curtain by generating metaphorical associations, the wall, which is usually made of a light and transparent material such as glass is physically suspended from the primary structural frame (see Fig.28). Out of Mies van der Rohe's architectural designs, the Lake Shore Drive Apartments and the Seagram Building in New York are excellent examples of the curtain wall system.

The Seagram Building, finished in 1957, provides a modernist interpretation on Semper's paradigm of the Caribbean hut. The structural frame of the building has become secondary in importance to the cladding material visually and structurally. The internal structure is hidden completely, allowing the cladding elements to define the building. The Seagram Building, like many of Mies's other office buildings, is constructed out of concrete, steel and glass. To him, these materials represented efficiency and clarity of a new modernist age.

'Reinforced concrete structures are skeletons by nature. No gingerbread. No fortress. Columns and girders eliminate bearing walls. This is skin and bone construction.' (Johnson 1978, 188.)

Fig.30

(Fig.30)

The Seagram Building, Mies van der Rohe, New York

Technical and structural advancements during the previous century were supplemented by theories, opening up opportunities to experiment on a concrete level. Mies, along with those before him, redefined the role of the architectural wall. The box-like mass of the typical building was transformed into a filigree structure during modernism.

There existed three main design paradigms for this new architecture. For instance, buildings were designed around a grid provided by the skeleton structure (see Fig.31 and Fig.32). Also, exteriors became weightless, transparent and non-load bearing with the structure receding to center of the plan. Finally, the use of color and structural detail were treated as the new ornament, doing away with superfluous additions. New systems of construction as well as architectural aesthetics were formed on the basis of the redefined tectonic relationship between load-bearing structure and wall. (Johnson 1978, 30-43).

Fig.31

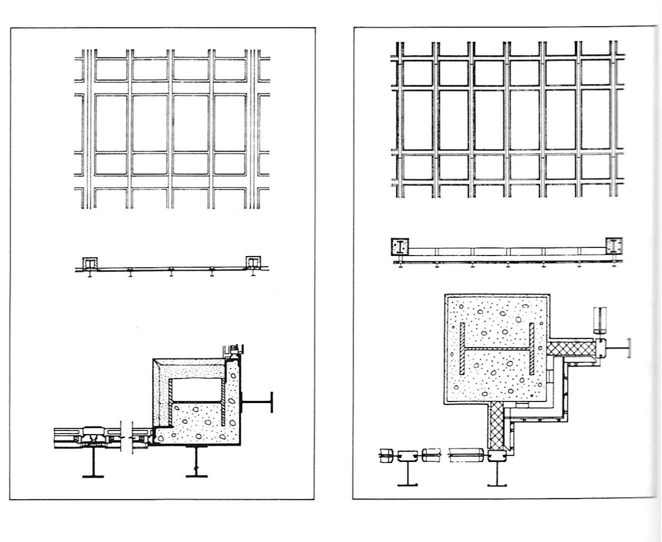

Fig.32

(Fig.31)

The curving curtain wall seen from the interior. Mies van der Rohe, Tugendhat House, Brno, Czech Republic

(Fig.32)

The structure forms a grid-like lattice on the exterior of the building. Curtain wall details for apartments. Mies van der Rohe, 860 and 880 Lake Shore Drive Apartments, New York

3.4.2

Re-emergence of Semper’s paradigm?

Finally, returning to Semper's original paradigm, textile as material has finally replaced architectural materials in Shigeru Ban's Curtain Wall House, which was built in 1995. Concluding a journey, which began at the highly conceptual, this building applies the concept of the curtain wall by literally employing textile in place of a solid masonry wall. The textile material is similar in color and reflectiveness to the white rendered masonry walls and roof element, making its only distinguishable feature its thinness and mobile nature. This is a surprising, tongue-in-cheek approach to the seemingly endless debate on the role of the architectural wall.

Fig.33

Fig.34

(Fig.33)

Shigeru Ban, Interior of Curtain Wall House

(Fig.34)

Shigeru Ban, Exterior of Curtain Wall House, with curtain open

4 Summary of Findings

4.1

Introduction

Through researching theories and examples of architecture, it is clear that links have been formed between architecture and textile. These connections exist on numerous levels and have remained present through various stages of history. For instance, key events during the eighteenth and nineteenth centuries, such as the Structural Rationalist movement and Industrial Revolution, shifted design paradigms within the field of architecture.

As a result of this condition, technical developments in combination with novel theories eventually crystallized into examples of architecture. It could be argued that these paradigm changes were a critical response to the stagnating state of architectural design at that time. Instances such as the Seagram Building in New York and Adolf Loos' interiors still stand as concretized examples of this period of time, acting as precedents for today's designs.

For clarity, it was necessary in this thesis to divide the mass of knowledge available on this subject into two major categories. The first titled *Relationship of Ornament to Structure* and the second *Relationship of Parts to a Whole.* These categories will be summarized in short in the coming section.

4.1.1

Summary of Relationship of Ornament to Structure

The first section discussed the tension between ornament and structure in both architecture and textile. It applies to the visual language in architecture or the message that a building conveys via its façade. This shared condition is illustrated through the historical development of attitudes towards ornamentation and its role within a building. Beginning with the Renaissance, ornament's changing relationship to structure is traced through the Vienna Secession to modernism. The practice of purely decorative incrustation in architecture is finally replaced by a completely new definition for ornament: function. Simultaneously, a second branch of thought relating to the individual function of building elements began to develop.

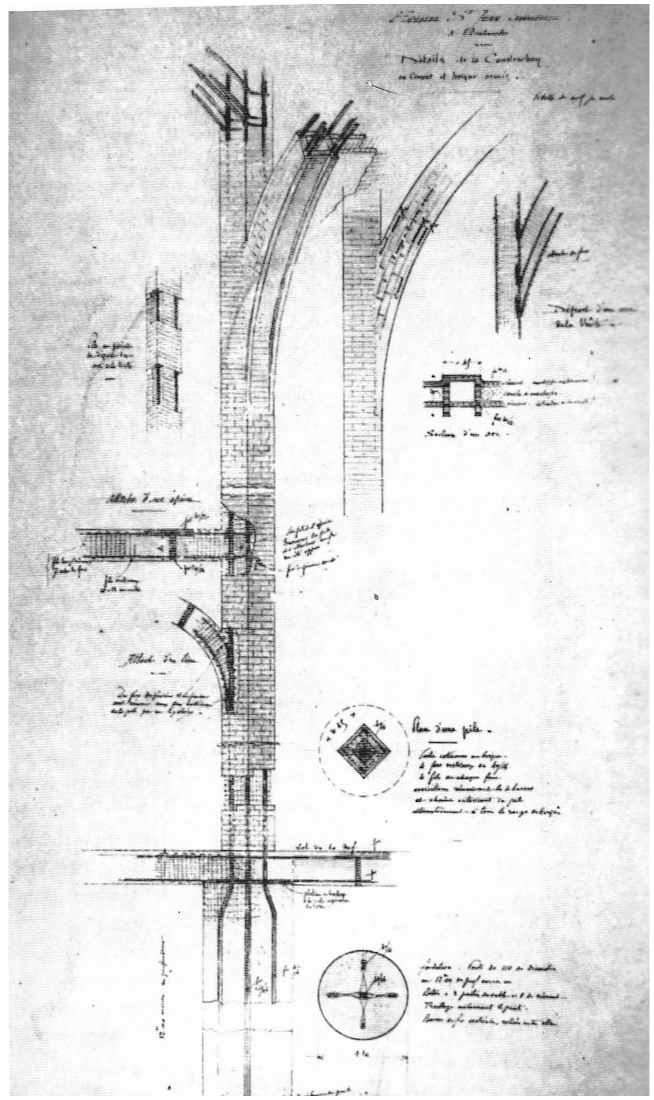

Fig.35

(Fig.35)

Anatole de Baudot, St. -Jean de Montmartre, Paris, 1894-1904. Drawing of reinforcing rods running through brickwork. This system of construction was one of the first to use the internal reinforcements of masonry walls on the exterior as ornament.

(Fig.36)

Le Corbusier, The Villa Savoye, Poissy, France

Fig.36

4.1.2

Summary of Relationship of Parts to a Whole

Section two was based on the wall's treatment as a textile-like element within the larger context of the building. Through the theories and works of Semper, Ruskin and Mies, it was possible to see that both architecture and textile components are employed in a similar manner within the whole. The development begins with the primitive wall, which is made of a frame and woven covering (see Fig.37). From this pre-architectural condition, the role of this textile component becomes increasingly distanced from its structural support. This results in the exterior of the building moving gradually further from the load bearing interior. This condition was best exemplified through Mies van der Rohe's early curtain wall schemes (see Fig.38 and Fig.39).

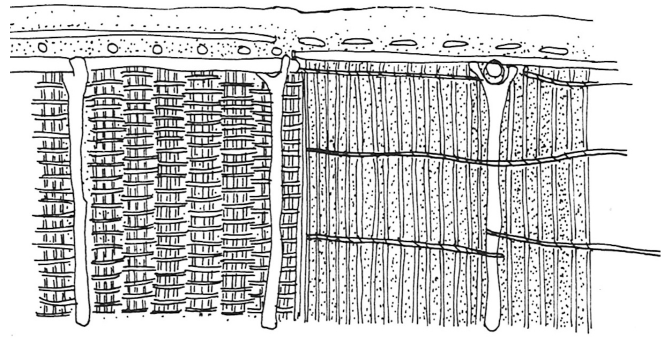

Fig.37

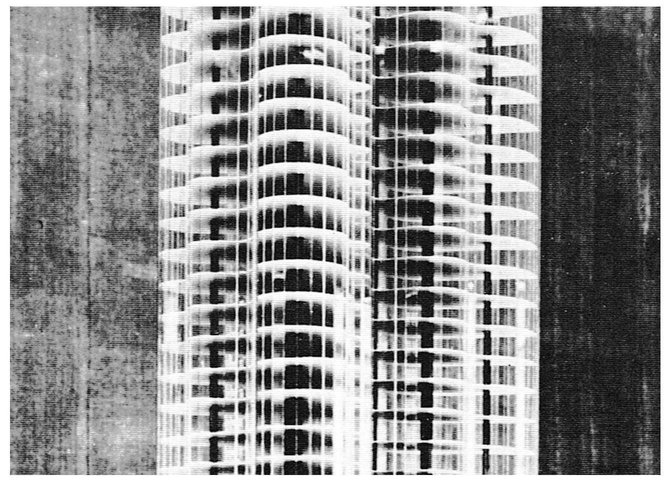

Fig.38

Fig.39

(Fig.37)

Detail of wall infill, Gogo house in Tanzania

(Fig.38)

Mies van der Rohe, model of glass skyscraper project

(Fig.39)

The curtain wall concept applied on the interior of a building. Mies van der Rohe, dining room of Tugendhat House

4.2

Shared Principles between Architecture and Textile

4.2.1

Functional by nature and instinctively ornamental

The nature of both buildings and fabrics is initially functional, but they have throughout time been adorned in innumerable ways for various purposes. Also known as the 'humanization' of the environment, it seems humans around the world have been drawn to decoration after the basic needs of security and comfort have been met. The motivations behind decoration for both textiles and built structures can be religious, spiritual or cultural (see Fig.40 and Fig.41). Ornamentation is driven by an intellectual urge and can be viewed as an extension of an invisible, mental structure. (Engel 1981, 9).

Fig.40

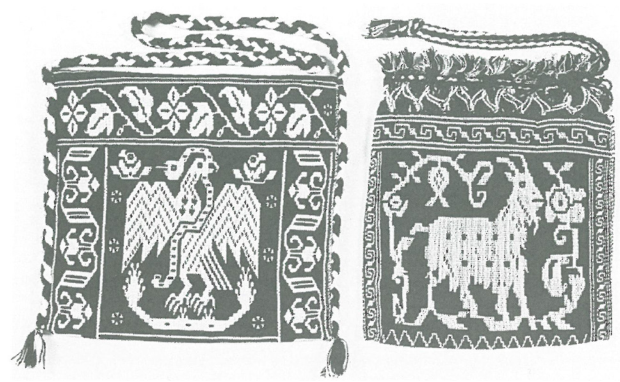

Fig.41

(Fig.40)

Ornamental house front. Vernacular architecture in Zinder, Niger

(Fig.41)

Double-woven Otomí bags. Mezquital Valley, Mexico

This common state of existence may have sparked the need to question the use of ornamentation in both fields of textile and architecture. The difficult co-existence of tectonics with representation is born from this shared intrinsic nature of necessity. When considering any constructed surface, some of the most influential debates within the field of architecture concern the dichotomy of form and function, which can be seen as the tension between ornament and structure.

This concept of form and function has been the driving force behind numerous movements, influencing major architectural styles throughout history. These movements have attempted to formulate clear paradigms for the interrelatedness of tectonics and representation on buildings and within these movements are theorists who have drawn on textile concepts to understand the nature of the architectural envelope and its relationship to structure.

Fig.42

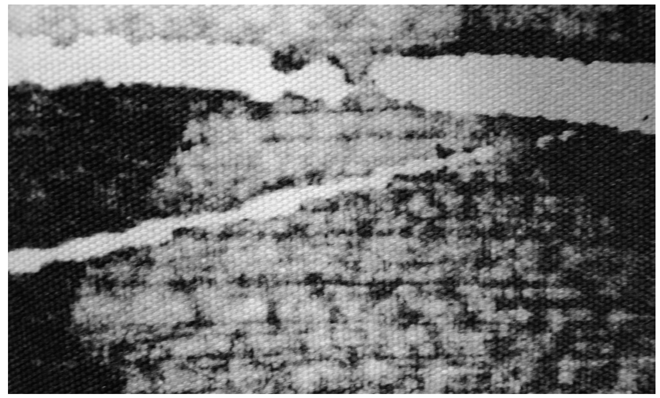

Fig.43

(Fig.42)

Example of recent architectural ornament, a transparent steel mesh on the facade of the Birmingham Public Library by Mecanoo architecten, UK, 2013

(Fig.43)

Ornament can also be applied through printing textiles. Here, the structure of the fabric can still be recognized under a layer of color. Digitally printed canvas, own work, spring 2013

4.2.2

Beauty at the expense of utility

Architecture holds a precarious position between beauty and utility, its very nature is contradictory. Choosing between the two may seem simple; most would prefer a building that keeps the rain out as opposed to a building with no function. Subject to real, existing forces of nature, humans instinctively value utility over beauty, but the interrelatedness of usefulness and aesthetic pleasure is complex.

Some architectural movements have emphasized the usefulness of beauty through applied decoration. Conversely, through modernism utility became seen as beautiful in itself. Another example is everyday objects such as garden sheds and burlap sacks. They are produced for purely functional purposes, visually stripped down to the bare essentials required for them to perform their allocated task. All decoration is viewed as superfluous and cumbersome in these instances also.

The question is, does the shed and the sack constitute as architecture and textile? How much does a garden shed have in common with a Renaissance cathedral? Through experimentations with the identity of architecture and textile, a variety of movements and styles evolved.

As a result of these fluctuations, a large degree of expediency became tolerated and even necessary to both fields. Toggling between pure decoration and functionality in textile is what lends dynamism and richness to the field much in the same way as the debate on form and function keeps evolving architecture.

Fig.44

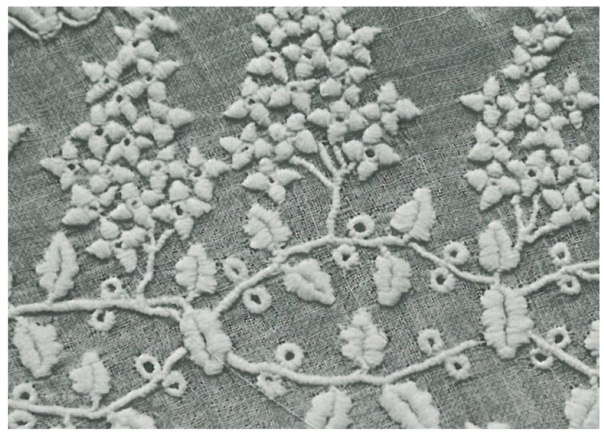

Fig.45

(Fig.44)

Adorned facade. Murcia Cathedral, Spain

(Fig.45)

Embroidery is a commonly used method to cover an underlying fabric with ornament. Whitework, or sewed muslin from the 19th century

Within architecture and textile, this tension between beauty and utility has been studied through the hiding and revealing of structure. Usually through the application or removal of surface material, the functional properties of an object are either covered or left exposed. For a large part, this practice has been driven by visual aspects.

Pre-rationalist ornamental incrustation is an example of representation completely or partially masking the tectonic (see Fig.44), whereas the Structural Expressionist architecture of the late twentieth century articulates structural functions on the exterior of the building (see Fig.46). Textile equivalents following this same principle can be found in Figures 45 and 47.

The first example represents traditional ornamentation practices in architecture, but the same method can be seen in textile practices also. The latter is an example of structure as ornament, where the traditional identity of ornament has been altered. Here, the tectonic aspects of a building or textile serve as optical enhancement also.

Unlike in architecture, the chronological development from incrustation to structural expressionism is not as visible in textile. Despite this, ornamental value has been derived from structure in textile also. Between these two extremes exist varying degrees of integration between the optical and functional. For instance, adorned cornices on buildings and weaving techniques that derive ornamental pattern through structure are connected by the desire to add beauty to a surface by following the underlying structure.

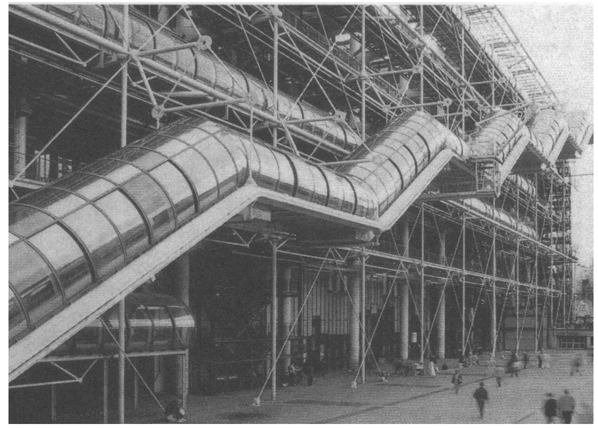

Fig.46

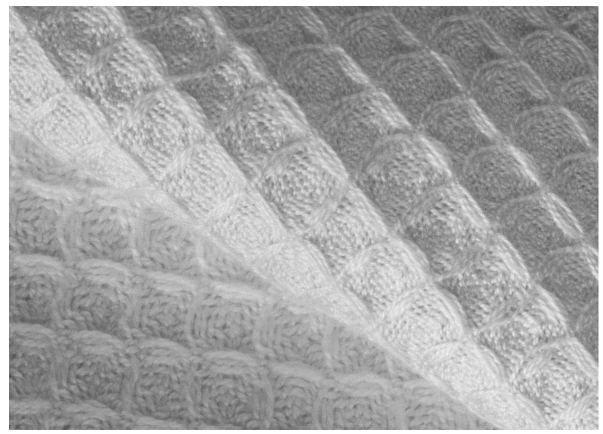

Fig.47

(Fig.46)
Structure can have an ornamental role. Renzo Piano and Richard Rogers, Centre Pompidou, Paris
(Fig.47)
The intrinsic structure of the fabric creates a pattern on the surface. Waffle weave, cotton yarn

4.2.3

Built from structures

Many components are involved in producing textile as well as buildings, but without structures, it would be impossible for either to exist. Paint can be removed from a wall without changing the wall's identity because it is not directly forming the wall. (Engel 1981, 19). Also within a textile context, the organization of individual yarns or fibers to produce a surface defines textile from plastic. Whereas paint or other superficial additions are not vital to a wall's existence, the wall could not exist without structure. In spite of this inevitable condition, mere structure does not make a work of architecture or fabric, but it acts as an essential facilitator toward the final goal. It is largely through the influence of nineteenth century Structural Rationalist thinking that we have come to perceive buildings as composites, made up of structures and various other components.

Within the disciplines of architecture and textile, there are innumerable options for structure. Responding to major technological advancements throughout history such as the invention of modular building systems or the jacquard loom, both architecture and textile industries have developed more complex structural systems.

In each field, all physical material such as wool or steel is organized by using structural systems and much like in architecture, the structure of a fabric can be made visible or hidden in the final outcome. Despite this, these shared structural systems between textiles and architecture should be viewed as conceptual, due to the drastic change in scale between the two objects.

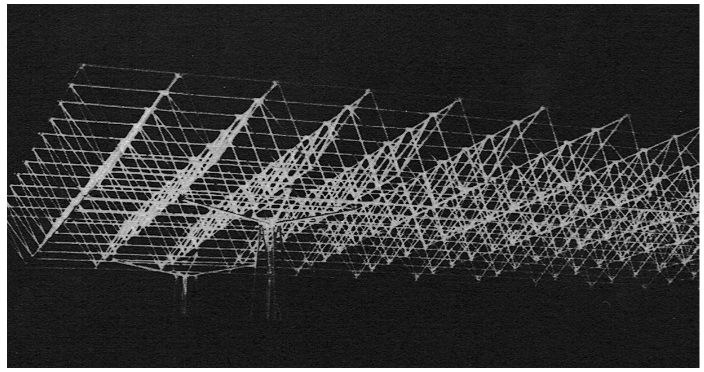

Fig.48

Fig.49

(Fig. 48)

Flat trussed space frame structure system

(Fig. 49)

Close-up of waffle weave structure

As mentioned earlier, architectural and textile objects are fabricated from a wide range of structures. Some structural typologies are based on the number of layers used. In both fields objects can be built up from layers or the functions of these layers can be integrated into a single membrane-like surface. For instance, most walls in houses today will consist of a series of layers constituting the exterior cladding, insulation, primary structure and interior cladding.

Opposing this typology are stressed skin constructions, which combine two materials and their intrinsic functions into one single functioning surface. The composite action of the two materials lend the structure a characteristic structural function, that would not exist without both components.

The structural use of layers is central to the concept of dressing in architecture. The idea of a frame around which another material is draped can be seen on a number of levels in both architecture and textile practices. The essential components of this system are the exterior, non-structural material and the supporting frame. This can be can be seen in curtain wall structure systems.

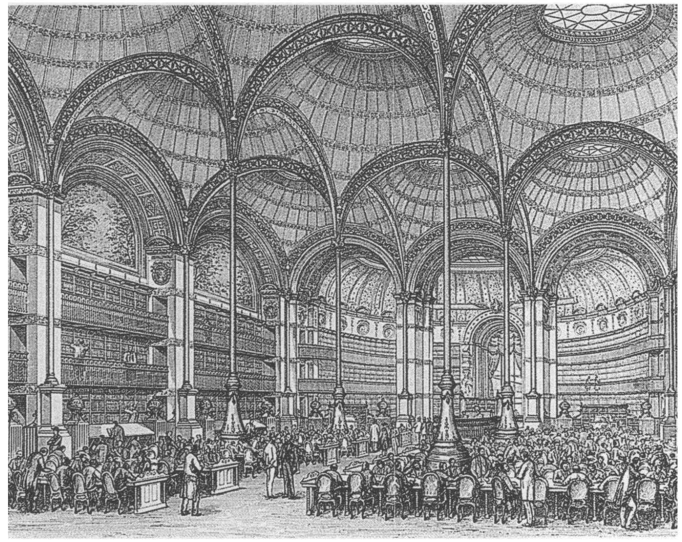

Fig.50

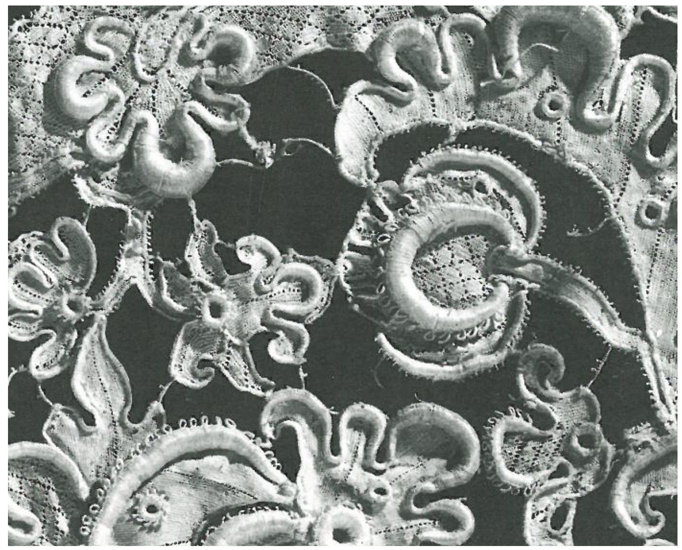

Fig.51

(Fig.50)

Cladding and structure fuse into one membrane-like surface. Henri Labrouste, Bibliothèque St. Geneviève, Paris

(Fig.51)

The structure of lace acts also as an ornamental feature. Venetian gros point, circa 1670

5 Conclusion

5.1

Conclusion of Findings

Despite being treated as separate entities within the context of this thesis, the two sections are not mutually exclusive. Throughout each development phase, there are crossovers between the visual tension between ornament and structure and the arrangement of the wall in a building. For example, the structural details enabling a glass curtain wall to float separately from its supporting structure can also be seen as ornament. Particularly during modernism, the shift in ornament's ontological identity coincided with advances in tectonics.

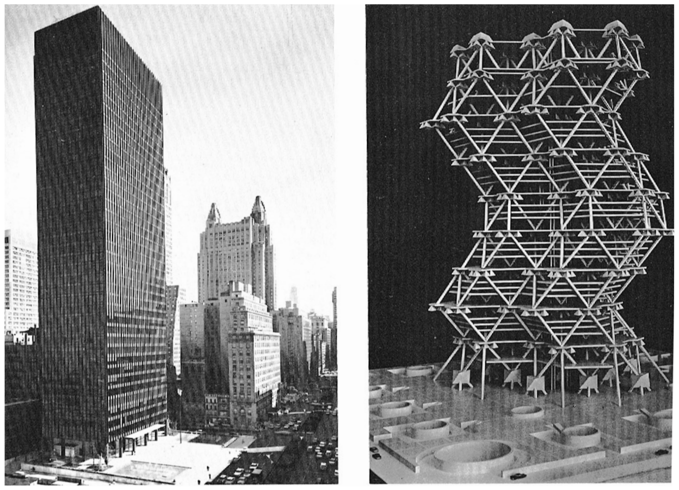

Fig.52

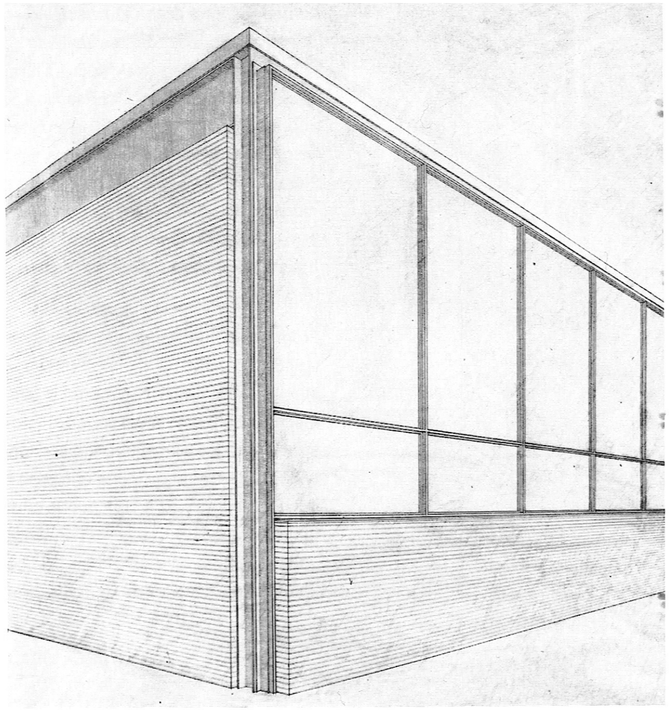

Fig.53

(Fig.52)

The load bearing structure is hidden within or exposed on the exterior of the building. A comparison of The Seagram Building by Mies vand der Rohe and Johnson and "Tomorrow's City Hall" by Louis Kahn.

(Fig.53)

The corner detail of this building gives a sense of layeredness to the exterior envelope. Mies van der Rohe's Library and Administration Building, Illinois Institute of Technology, Chicago

5.2

Contextualizing the Findings

Looking around urban environments today, it seems that the ornamentation of façades has again become more common. Unlike its historical predecessor, which was often formed from stucco, metal or clay, this new decoration is most often seen on glass surfaces. These visual additions to glass surfaces are achieved through etching with acids and lasers or by printing. The theme and appearance of the decorative motifs vary greatly, ranging from single blocks of vivid color to intricate arabesques.

Vast expanses of glass on façades have remained with us since the invention of the curtain wall and will most likely remain with us for longer still. The crystalline curtain wall stood for ideals of structural and material honesty, an ideal most vehemently embodied by the modernists. Today, instead of a revealing the underlying structure as before, these surfaces conceal it through ornament.

One benefit of covering glass surfaces with a thin layer of material or treating it to be translucent is controlling heat gain through direct sunlight. It is difficult to believe this is the only motivation behind this decoration phenomenon though. Could the application of this type of ornament also be a counter-reaction to the modernist utopia of a gleaming cityscape? The principle regarding the need to 'humanize' the environment could be studied further for answers to this question.

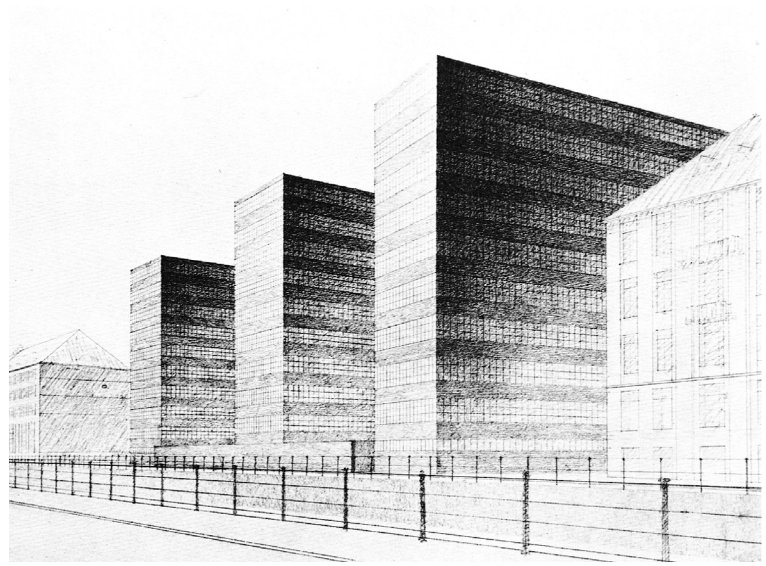

Fig.54

(Fig.54)

Sketch by Mies van der Rohe, Reichsbank, Berlin

In light of the theories discussed, current architectural developments could be seen as a type of 'new incrustation' altering again the existing relationship between ornament and structure. In addition to denoting physical coverage, the term of incrustation also suggests a range of problems this approach originally faced. Upon immediate inspection, these new decorations seem to have no clear connection to their built, structural surroundings neither physically or by visual reference. Critics such as Karl Bötticher and other rationalists condemned incrustation as superficial and indifferent to the underlying structure for instance. Could the practice of decorating, now glass facades, face opposition once again?

Fig.55

Questions that may arise to the critical viewer may be related to the driving force behind these pictorial motifs. What are they founded upon? What is the function of this piece? Does it compliment the structure around, or is it concealing parts of it? What is behind this particular architectural treatment, both visually and ideologically?

Fig.56

(Fig.55)

Facade of apartment block built in 2013, Tampere, Finland

(Fig.56)

Graphic Concrete. Patterns are etched onto the surface using an acid. Provincial Archives of Hämeenlinna, Finland.

In an attempt to liven up cold, impersonal space within a city, permanent poster-like attachments have been installed onto buildings. These decorative elements adorning buildings are excellent examples of graphic design, but they usually offer no reference to the building upholding it. No message is discernible to innumerable viewers on a daily basis.

If this ornamentation is meant to be viewed as part of architecture, creating a connection with its built surroundings would render these visual additions less disconnected from their architectural context, bringing them out of the realm of pure decorative art. As some of the most severe critics of ornamental incrustation have already pointed out: the disconnection between a built structure and its ornamentation denigrates an otherwise multifaceted discipline into a practice of illustration and masking. Architecture cannot escape its functional nature and therefore cannot be treated as a form of art only. The identity of architecture as a practice is founded upon this paradox.

Fig.57

Fig.58

(Fig.57)

Facade of John Lewis department store, Leicester UK. Foreign Office Architects

(Fig.58)

Facade of student housing in London, UK, 2013

5.3

Endnote

When beginning research for this thesis, the tension between applied decoration and structure was familiar in architecture, but surprisingly a similar tension exists in a textile context also. Further research into the topic revealed an unexpectedly wide range of shared qualities between the two fields. For clarity, I chose to focus on two in this thesis.

Coming from a background in architecture, I approached weaving from a more structural perspective rather than focusing on visual aspects. The dialogue that exists between decorativeness and the systems that bind materials together became increasingly apparent while weaving. The content of Part II of this thesis is the result of a process to understand the tectonic systems governing both architecture and textile.

Through the methods of research and artistic production, three underlying principles between architecture and textile were found. These relate to the human instinct to adorn, beauty at the expense of utility and the necessity of structure. All of the above can be found in textile and architectural practices today.

The connection between the two fields was processed artistically as well as through research. Despite using two methods to investigate the topic, the sample of textile and architectural structures studied in this thesis remains narrow. Conducting a more extensive study on this subject would provide valuable additional information. There are numerous structural typologies that were not covered in this thesis, for both textile and architecture.

The thesis has focused mainly on woven structures, but another topic that would have been fascinating to study are the structural properties of printed textiles. Instead of yarn, pigment or paint is applied to textile surfaces. The degree that the dye affects the internal structure of the yarn can vary greatly and produce unexpected structural results.

It was also necessary to set a clear framework for the work to avoid detracting from the subject area. The issues studied were originally difficult to structure due to their abstract nature, but the seemingly unlikely combination of architecture and textile produced an abundance of new directions in design. On the contrary to being entirely conclusive, this work has opened up a wide range of questions and possibilities for further investigation.

6

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Part II

Applications

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Introduction

In architecture, understanding certain structures is sometimes possible only if they are physically drawn or modeled. Through this process, which is often slow and even meditative, new associations and ideas may arise relating to the underlying properties and principles of the structure. This method has proven indispensable for achieving a deeper understanding of textiles also.

Through weaving and felting, it was possible to better understand material behavior and the physical properties of woven surfaces. Much like architecture, the woven fabric is represented through two-dimensional technical drawings. A great deal of information regarding the manufacturing of the textile can be read from this binary notation, but full understanding is achieved when it is possible to physically see and feel various materials functioning as part of an overall structure.

By making samples of textile along with architectural drawings, it is possible to further explore the topics discussed in Part I of the thesis. The theories center on two topics: the relationship of structure to ornamentation and the relationship of parts to a whole. By studying the historical developments within these two categories, it was possible to find common principles behind architecture and textile.

The following section draws connections between the textile samples and architectural drawings. These are either on the level of material properties or on the level of structural organization. For example, the surface of a tablecloth made in plain weave is reminiscent of a lattice structure on the façade of a building. Friction is enough to hold the thin cotton yarns together whereas in a steel frame, joints and bolts made of steel are used to keep the crossing members in place. Despite differences in scale, the objects of this next study are defined by the same organizational principles.

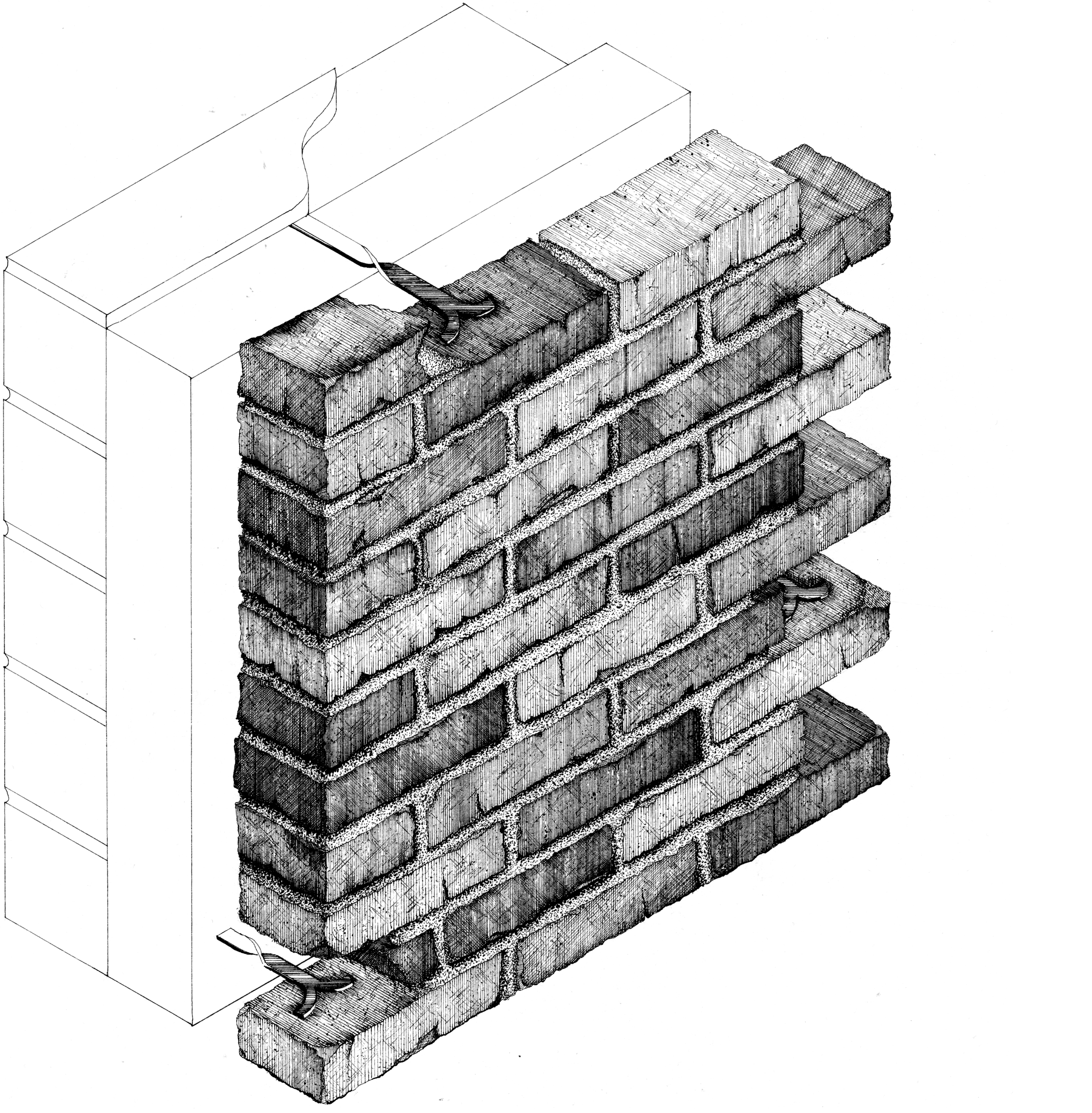
1 Brick Wall and Satin

1.1

Introduction

The word incrustation describes the act of physically covering a surface with another material, thus hiding what is underneath. Literal examples of incrustation in textile would be tapestry, printing and embroidery. These methods apply ornament directly onto a textile surface, sometimes with the intention of covering it completely. As an architectural counterpart, applied stucco ornament onto building facades illustrates the principle of incrustation well.

The above mentioned practices lack a clear relationship between structure and representation, whereas a brick wall and woven satin retain this connection. These two systems promote the effect of incrustation yet maintain a clear relationship between structure and ornament, making them tectonically more integrated. Drawing from a wealth of woven textiles and commonly used architectural systems, the tectonic principles of brick and satin structures were most relevant to this thesis.



1.2

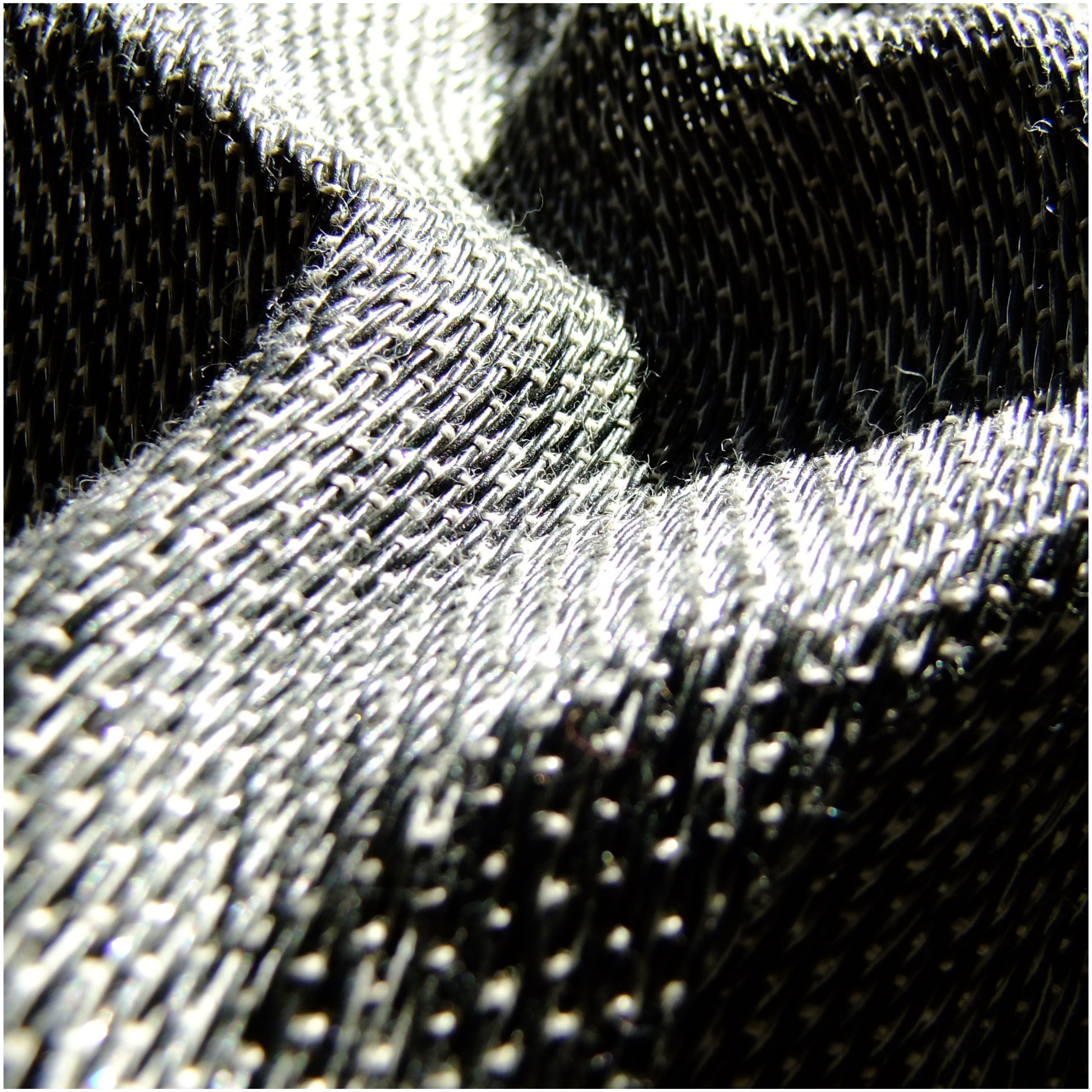
Brick: analysis of the fundamental principles of material organization

Materials used for exterior cladding include any lightweight material attached to the load-bearing structure such as thin slabs of concrete, timber shingles or stucco. Conceptually thinking, this outer layer is indifferent to the underlying structure, but in a tectonic sense, the two elements may still be working as a system. Drawing on the wide variety of cladding materials in a similar tectonic relationship with the primary load bearing structure, the choice of brick should be justified here.

Brick is an extremely versatile material that can form pattern, single images or a continuous surface, depending on the choice and arrangement of single brick units. Depending on its properties, it can be used as a cladding material or as part of the structure. Of equal importance with the single brick unit are the bonds that tie the pieces of individual masonry together and these bonds are usually created through mortar.

The integrated system of bricks and mortar produce a surface that is simultaneously fragmented and unified, the method of construction clearly articulated in the relationship between the unit and its infill. Also much like weaving, bricklaying is based on a clear principle of organization within which exist innumerable variations. (Deplazes 2005, 43-48.)

Due to the solid appearance of brick cladding, the wall is often thought to be constructed purely of this one material, but especially in colder climates there is often a separate, load-bearing wall behind, supporting what is only an exterior layer of brick. Despite appearing separate from each other, the brick façade is attached to the load-bearing structure using what are commonly known as wall ties. Placed at appropriate intervals, they provide an anchor between the facing brick layer and the underlying support structure. Although visually separated, the exterior layer and interior structure still function as an integrated system.



1.3

Satin: analysis of the fundamental principles of material organization

The qualities of satin are often described as smooth, silky and lustrous. The choice of yarn plays a fundamental role in the appearance and feel of the fabric, but this particular smoothness is also achieved through weave structure. The satin weave, along with plain weave and twill, is one of the three basic weave types and possesses a counterpart: the sateen (Willman & Forss 1996, 54). This particular example is a sateen, which is a weft faced satin.

Experimenting with these weave structures revealed that satin's warp to weft ratio, which can be seen on the front and back of the fabric, is the most imbalanced out of all weave structures. Particularly in satin weaves with longer weft floats of 8 or 16 picks, the point where the weft yarn is tied down is almost unnoticeable. In the case of longer weft floats, the warp yarn is tied down at fewer intervals, leaving the yarn free or 'floating' until the next tie down point. This feature is what keeps a satin weave working as a single piece of fabric and integrated structure, instead of two separate layers or material.

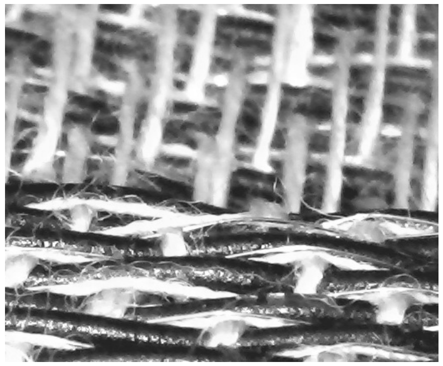
The weft facing side of the sample is not indifferent to the underlying warp facing side though. This particular weft faced satin surface is the product of the underlying structure. With prior knowledge of weaves it is possible to discern from the surface that this is a satin weave structure. Despite 'hiding' the underlying structure, the surface reflects what is happening underneath.

1.4

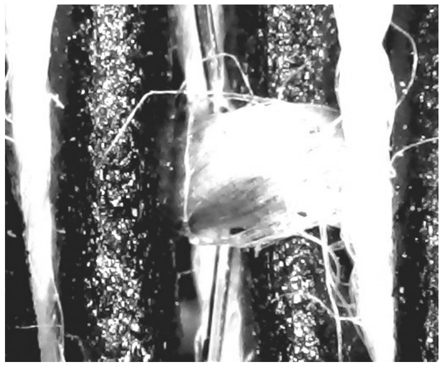
Conclusion: Layers of Material

By examining the structural principles behind brick walls and satin weaves, it is possible to discern similar organizational principles behind both structures. Both are based on a system involving two or more layers, which are all connected to some degree. Irrespective of scale, layeredness is achieved through the high degree of coverage afforded by the exterior layer, hiding what is underneath. Although the underlying structure remains completely covered visually, hints to the structure are exposed on the exterior. Traces of the invisible can still be spied on the surface.

To further underline the tectonic relationship of cladding and structure in a brick wall, the points where the two layers are tied together by wall ties could be articulated clearly on the exterior. This would reveal the connection between the interior and exterior in an easily discernible way to those without prior knowledge of wall construction, bringing the fundamental principles of structural organization in brick walls and satin even closer.



The front and back of the satin textile. The front is dominated by the long weft floats of polyurethane yarn whereas the back of the fabric consists predominantly of the linen warp.



The role of the linen warp on the front of the fabric is minimal, it is only used as a tie-down component for the weft yarns.
A close-up of the fabric surface.

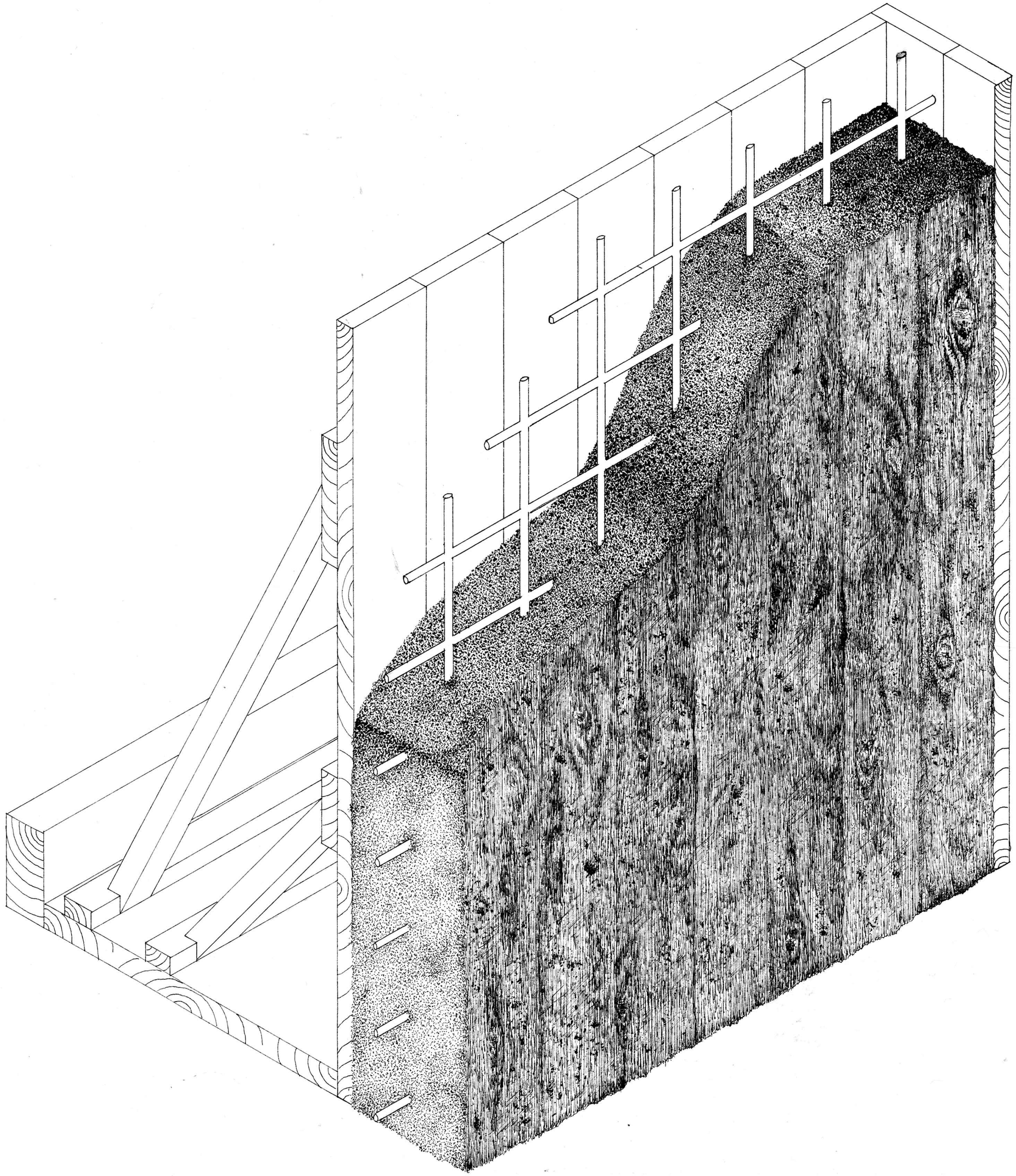
2 Poured Concrete and Felted Wool

2.1

Introduction

In this example, poured and reinforced concrete will be studied along with felted textiles due to their particular relationship with temporary structures. The presence- and then absence- of the initial structures used in forming the material is intriguing as well as the tectonic interdependence created from this condition.

In concrete, the aggregate and internal steel reinforcement are permanent whereas timber formwork is temporary. As part of the process for forming a concrete wall, the formwork is essential, yet it is a transitory component in the structure, removed after the aggregate is solid enough to maintain its own form. (Deplazes 2005, 56-57.) Because this thesis is examining common building practices found in any urban environment, the building element of poured and reinforced concrete could not be overlooked.



2.2

Reinforced and Exposed Concrete: Analysis of the fundamental principles of material formation

Concrete is one of the most ubiquitous building materials of this century. Chosen for its relatively efficient construction method, it has been used as both cladding and structure. Walls, long spanning shell structures and linear members such as columns and beams can all be fabricated out of concrete. The methods involved in forming concrete are equally as numerous. For instance, the material can be precast at a factory and installed on site or it can be cast in situ into a steel or timber formwork. The term in situ refers to the process of mixing and pouring the wet concrete into formwork on the construction site. After removing the formwork, the hardened concrete element is ready unless additional surface treatment is required.

Concrete is usually present as a single component in a larger built structure, but forming this material requires a tectonics-based process. Timber formwork and steel reinforcement function as an integrated system of two structural typologies with the poured concrete mixture. Concrete aggregate is a monolithic building material with mass and weight, whereas timber formwork and steel reinforcement are both exhibiting characteristics found in filigree structures such as low weight and temporariness.
They are both also grid-like, with each structural member visibly supporting and carrying loads whereas the mass of the aggregate disguises the flow of forces. After removal, the traces of the timber formwork are still visible on the exterior surface of the concrete. The structural steel lattice is invisible, enclosed within the concrete material and the formwork is transitory, leaving only behind traces of its existence on the surface of the hardened aggregate. Both structurally as well as process-wise, the concrete material mass and its filigree components are inseparable.

As a result of this condition, reinforced and exposed concrete has a different tectonic identity to a wall built from facing masonry and a separate supporting structure for example. Firstly, unlike a brick wall, there is no physical separation of exterior and interior wall elements in a single concrete element. The steel frame providing the tensile strength lies within the concrete prompting the wall to work as a single unit. Cladding and structure seem to have been combined into one single building element, suggesting to the onlooker that the condition visible on the outside reflects what is happening within the mass.

2.3

Felted Wool: Analysis of the fundamental principles of material formation

Felt is appreciated and used for its surface appearance and also for the excellent insulating properties of the wool fibers. Sometimes, dyed wool is used either randomly or to create an intentional pattern, but a single ball of natural wool possesses a surprising amount of variation as a material itself, which becomes evident in the final felted product. Mostly wool is used and is comprised of fine fibers that irregularly bind together to form a continuous surface when subjected to mechanical stress like rubbing.

The outcome of this process is a solid piece of material, as if it has been sculpted or shaved from a larger block, but as with concrete, the process of felting is additive, not reductive. Using a natural soap along with warm and cold water in turns, the loose wool, which is laid on a flat surface, is mechanically rubbed until the fibers begin to bind to each other.

After the base layer is dense enough, new layers of wool are added to the first until the desired thickness is achieved. The binding agent is the water and soap and the hands can be seen as the 'formwork', determining the final size and shape of the felted piece. Each hand-felted fabric has a unique consistency based on the pressure applied to the material and the direction of movement.

Much like in poured concrete, the process of material formation is visible on the surface of the material. In addition, both materials are monolithic in appearance and behavior. Physical forces such as tension and compression are not visibly distributed along individual fibers like in filigree structures, but are dispersed invisibly throughout the entire volume of the material.

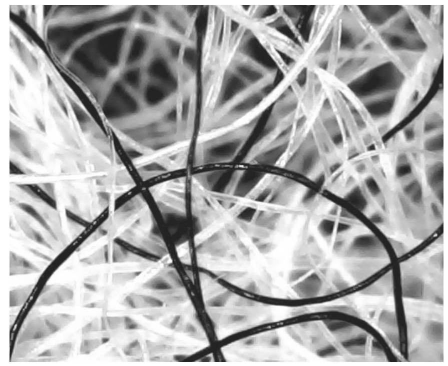
2.4

Conclusion: Exposed or hidden structure?

Choosing to study exposed concrete and felt in particular corresponds to the ideals of the architect Adolf Loos. As one of the pioneers to the modernist movement, he advocated 'truth in material'. Through the use of exposed marble or wood surfaces, Loos posed a new solution to ornamentation in architecture. In his point of view, it was possible to derive ornament and beauty through the material itself, enhancing its natural characteristics through surface treatments such as polishing.

Particularly when timber formwork is used, the concrete surface that has set against the frame is left exposed. In comparison with hidden, structural concrete elements, exposed concrete has a completely different ontology. Amidst endless options for rendering the concrete surface, it is always a conscious choice to leave concrete exposed and following Loos' approach, it can be seen as architectural ornament.

Despite this initial impression, the surface of concrete is not as 'truthful' as imagined. The exposed part of the concrete mass has been affected by the formwork and other factors such as finishes and weathering. A skin of a few millimeters exists between the outside and the material enclosed within. '…This is why concrete is not perceived as the natural building material it really is, but rather as an "artificial, contaminated conglomerate."' (Deplazes 2005, 56). Additionally, structural steelwork is hidden at the center of a reinforced concrete wall. When comparing filigree and monolithic structures, it is possible that the filigree is still seen as more 'honest' of the two structural typologies?



The organization of material in a non-linear way produces a different aesthetic. This felted prototype consists of individual wool fibers organized in a random manner. A photograph taken of the felted surface with a microscope camera.

3 Frame Constructions and Lenoweave

3.1

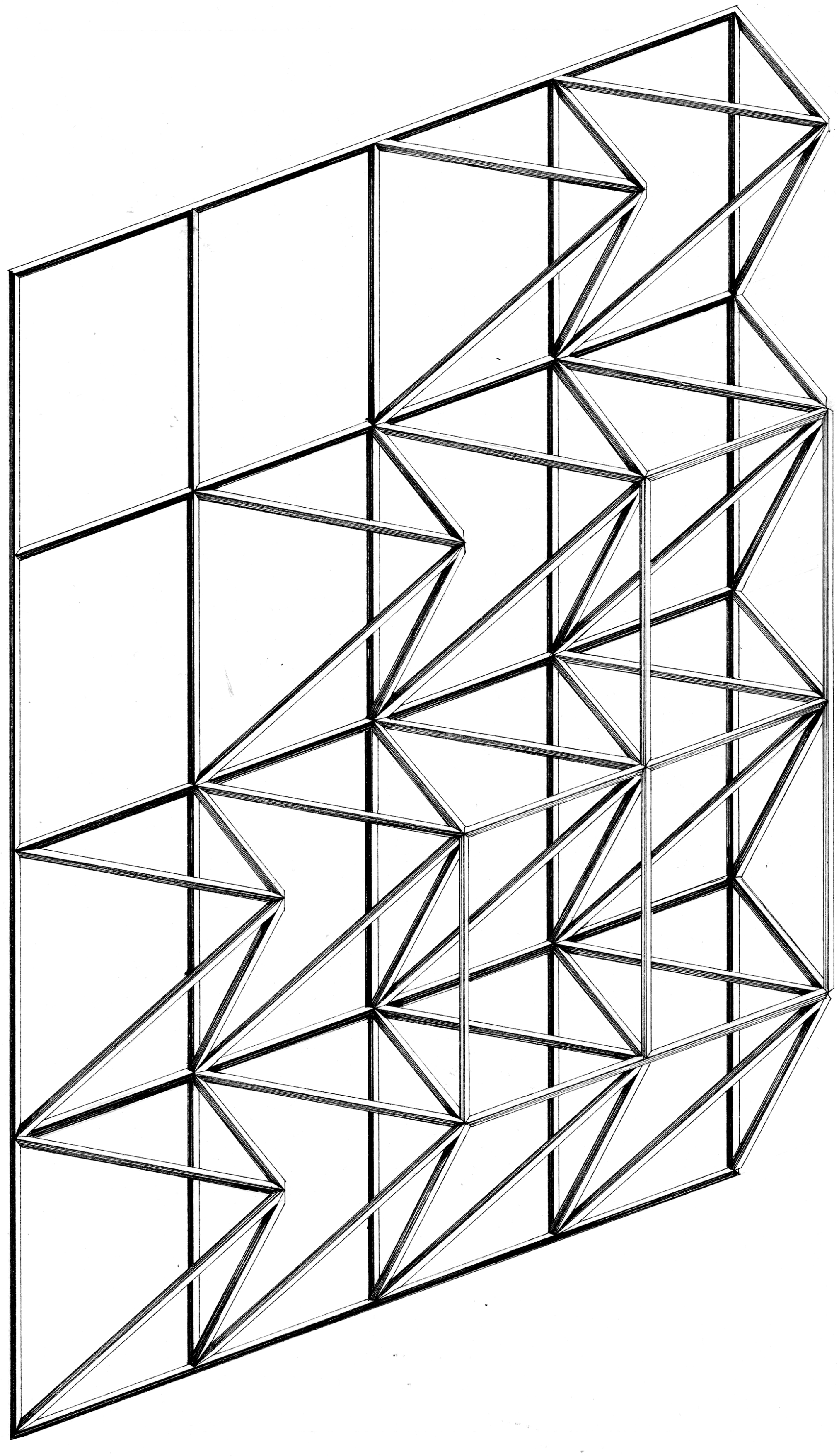
Introduction

This pair of examples will focus on the clearest example of a filigree structure: the structural frame. The frame is usually a component working within a larger building system and if it is enclosed within layers, it is more a means to an end. Alternatively, frames that have been exposed by stripping away all superfluous additions can be simultaneously structural and ornamental.

All architectural frames have evolved from a basic construction consisting of horizontal and vertical members. Items such as a table and chair embody the principles of frame construction in its most elementary state. The frame is based on linear members performing under either compression or tension and the linear components along which these forces are channeled distinguish filigree from monolithic structures.

Particularly the condition of tension is common to both fields of architecture and textile. Tension resistant linear members can be found in grid shell structures, cable bridges and space frames. In textile, the single filament or yarn, much like the linear members in a frame construction, is subjected to pulling and friction.

Additionally, yarns can be ‘knotted’ together to form joints or surfaces. Examples of this method can be seen in lace, fishing nets and the weaving technique of lenoweave. The lenoweave textile will be examined as a counterpart to the architectural frame because both are derivatives from elementary principles that all linear structural systems are based on.



3.2

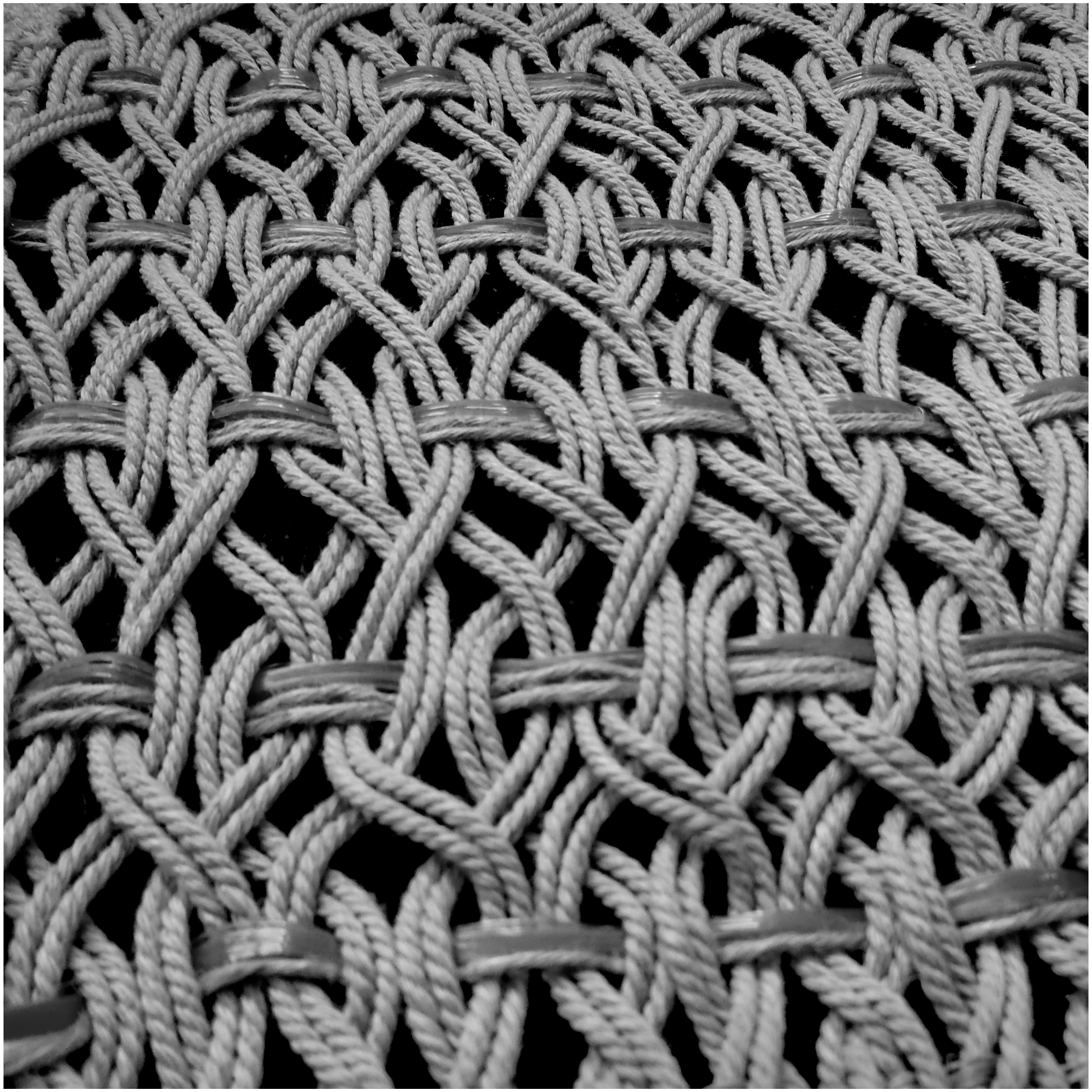
Space Frames: Analysis of the fundamental principles of material organization

The material of choice for constructing space frames is often steel. Owing to its high strength and low material usage, steel can be used to construct lightweight buildings of skeletal transparency. Originally this building type was intended for temporary construction purposes and like most filigree structures, this construction typology is based on economy of material. For instance, a space frame, which is four meters deep, can reach a horizontal span of up to seventy meters.

The linear members of this particular frame type can be joined together in a number of ways, eventually forming delicate, three-dimensional lattice networks. The deep cross section usually consists of triangular sections, which is the most structurally stable form. A typical example of a space frame consists of one top and one bottom layer that are either offset, differentiated or placed directly above each other. These are then connected via diagonal members resulting in a three-dimensional structure. (Borrego 1972, 134.)

Whereas other frame types often make up only a part of the structural system, space frames are left exposed on roofs and walls alike. Due to the short, straight linear members and their connecting joints, it is possible to use the same structural system for the entire building envelope. Frames can be hidden under cladding or integrated with other materials such as concrete in structural symbiosis, but the space frame is often left exposed.

Its articulated assemblage of the linear members and connecting joints exhibit what is occasionally referred to as the machine aesthetic. Integral to this style is the exposure of the functions of an object as opposed to hiding them under additional material. This system of construction and material were both products of the Industrial Revolution and were used as tools to convey a new design ideology. It embraced a logical construction method, where every structural member was reduced to the bare essentials. The exposed space frame is the embodiment of an ideology based on material and structural honesty.



3.3

Lenoweave: Analysis of the fundamental principles of material organization

Woven leno was traditionally developed in an attempt to make ‘economical lace’. Sometimes also called gauze or inglése, lenoweave has been used widely in Europe as a method of applying ornament to woven fabrics such as bed sheets or curtains. The lenoweave is known for its open structure and stability. This structural system is based on a structure of interlacing yarns and like in space frames, these connection points are an essential component in the structure. (Alderman 2004, 103.)

There are various systems available to make lenoweave, but the simplest method involves two thin, pointed wooden sticks, which are used to pick up the warp yarns and swap their places manually. Once their places have been switched, a horizontal weft yarn is passed into place to maintain the warp yarns in their switched positions. As a result, a succession of small joints or knots is formed. The point where the three yarns, the two switched warps and one weft, interact is the point with the most tension. This is because the warp yarns have been moved out of their natural positions and would return to their original state if it was not for the horizontal component blocking this movement.In the photograph, the weft yarn of different material is used to hold the warp yarns in place.

In comparison to its architectural counterpart, this type of weave is not the most three-dimensional out of all weave structures. It can at first prove to be difficult to see any similarities between the two until considering the system as a whole.

Loom woven ‘lace’ and vector active structural systems on a skyscraper hardly seem more distant from each other. Structurally, these two share similar principles though. Despite the open, filigree structure and sheer appearance, the linear components in the lenoweave fabric do not shift or lose form, but are held in place by the structure. Likewise, especially in space frames such as the one above, the linear members and connection points work in equilibrium for optimal structural stability. More important than superficial similarities regarding scale and appearances, are the common principles of structural organization shared by this particular weaving technique and construction system.

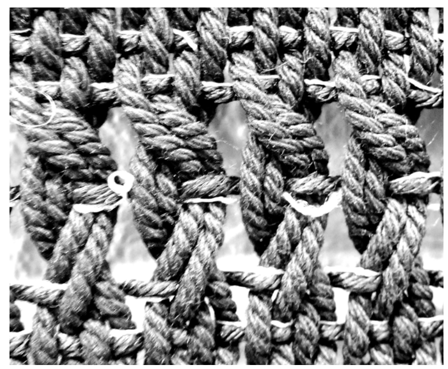
3.4

Conclusion: A closer look at the architectural joint and the defining feature of gauze

In his work *The Four Elements of Architecture*, Gottfried Semper underlines the significance of textile methods to architecture. 'The knot is probably the oldest technical symbol and, as I have shown, the expression for the earliest cosmogonic ideas that arose among nations.' (Semper 1989, 216.) Semper hints here that principles of architectural construction may have been formed on the basis of initial textile methods and materials. Discovering a key similarity regarding the tectonic relationship of architecture and textile, Semper brought the two fields closer together.

On a textile scale, friction is usually enough to hold yarns in place within a woven structure. In the example of lenoweave on the other hand, a type of joint is produced from crossing yarns. As a result, concentrated areas of material are formed, which direct the movement of the yarns. The use of this technique is what lends lenoweave its characteristic filigree quality. Similarly in architecture, without joining techniques, the formation of any structure based on the frame would not be possible.

On an architectural scale, friction is not enough and additional joining mechanisms are necessary to connect linear members. For instance, it is possible to weld the linear pieces together or use bespoke connections or joints. One ball-like connection, which is still in use today, was originally invented in 1942 and termed the "Mero" node. Designed by Max Mengeringhausen, it is used to construct frame mechanisms. This among many other bespoke structural connections, allow the direction of the linear members to change, distributing forces throughout the structure. (Borrego 1972, 18-19.)



A close-up of a typical lenoweave structure. To define the areas with interlacing yarn, a few rows of plain weave were added in between each row of lenoweave.

4 Frame, Infill and Double Weave Structures

4.1

Introduction

As mentioned in the previous section, Gottfried Semper made a connection between textiles and architecture on a number of levels, including within the context of construction systems. To summarize, Semper maintained that originally dwellings were constructed from woven textile screens, which were held in place by a frame. Aesthetically, it was the textile screen that was given precedence, not the structural frame, which counters the notion that architectural form is derived from structure. Here, the non-structural textile was given more architectural significance than its structural counterpart.

In Semper's theory, the relationship of structure to cladding comes under scrutiny and the pair of examples in this next section examine this relationship further. A more detailed account of his theory can be read in Part I of this thesis in the section termed *Textile origins of an architectural system* on page 29.

4.2

The frame and infill: Analysis of the fundamental principles of material organization

The frame and infill system is present in architecture on a large scale, but can also be found in the constructions of windows for instance. In this example, the focus is on the functioning of these components as part of a larger, complete structural system. For example, this drawing could be a conceptual representation of a curtain wall in a skyscraper. For further details, refer to Part I on pages 36 to 38 (Figures 28-32).

This organizational system is based on a primary or secondary load bearing structural framework paired with an additional filler material. Here, the filler does not have the primary structural role, but is often used for other purposes which can be aesthetic or functional. The frame is constructed out of any material that is resistant to both tension and compression. Common frame materials include steel or other metals, concrete and timber. There is a wider range of infill materials available due to lower structural requirements. These can be glass, brick and masonry, timber and other fiber based composites.

These structures are by nature filigree. As opposed to Semper's paradigm, where the textile element would cover the underlying structure, it is common to leave the structural framework exposed, often deriving aesthetic value from its grid-like organization. As a result of this attribute, this structural typology was particularly admired by modernists and still used widely today.

A pre-modernist example of this type of structure can be found in Part I on page 49 (Figure 50). The roof of architect Henri Labrouste's Bibliothèque is constructed from a cast iron lattice, with a mesh and plaster infill. The cast iron structure is in stark opposition visually and structurally to its filler counterpart, accentuating the relationship between frame and infill.

4.3

Double weave: Analysis of the fundamental principles of material organization

Double weave, also called tubular weave, has woven bindings that enable a more three-dimensional fabric structure. Two or more layers of textile are woven simultaneously on top of each other. Additional three-dimensionality can be achieved through having two looms on separate beams that can be moved individually. The two layers of fabric can be tied closely together or left open.

In weave structures such as piqué the weft can be used as ‘stuffing’ for the fabric. This also creates a distinctive, three-dimensional surface, but the double weave produces fabrics with a characteristic spatial quality due to the different ‘planes’ created that leave empty space in between. Due to this empty space, double weave textiles have been traditionally appreciated for their excellent insulating qualities. (Alderman 2004, 157.)

It is possible to ‘tie down’ the two individual layers. The layers often have two different weave structures, but together they form durable, single layer fabrics. In addition, a geometrical pattern may result from the interplay of the two weave structures. Alternatively, is possible to weave two fabrics completely separate from each other. There exists a large degree of variation between these two extremes and it is possible to produce surprisingly three-dimensional prototypes that are more reminiscent of architectural structures than traditional fabric.

The double weave structure allows the interchanging of two layers of woven surface. In the fabric of the photograph, the surfaces of the fabric are freed and attached to each other at regular intervals. Material and weave structure play equally important roles in forming the appearance of this fabric. The weft yarn materials are in dialogue with the weave structure, creating three-dimensional hollow spaces within the fabric through forces of tension and compression. The thicker and stiffer mohair is in structural opposition to the thinner, elastic crepe wool creating distortion in the surface. The two forces strive for equilibrium according to their material properties.

Stability in the textile is achieved through binding the two layers and different materials together into one homogenous surface. This ‘framework’ created through weave structure holds the more unruly areas of the surface in place.

4.4

Conclusion: surface-active construction as a more advanced frame and infill?

Surface-active structures obtained their name from the planar quality of the construction system and can be seen as a further stage of development of the frame and infill system.

Much like the previous frame and infill, surface-active constructions work as an integrated system. A stiff plate is inserted between the linear members to cover the openings. These systems have far more structural advantages to the traditional frame construction such as increased stability and stiffness. The complete structure remains stable because each flat segment supports its neighboring segments, preventing them from buckling under applied loads.

Materials, which cannot normally be used on their own in structures due to brittleness, function well in surface-active systems. Such materials include aluminum, steel sheeting, plywood or even plastics. In this structural typology, stress distribution is along the surface of the material instead of directed at a single point, making it possible to use materials that are not usually considered structural, such as plastics. Depending on the material, surprisingly high stress resistance can be achieved in these structural systems.

What is remarkable about surface-active structures is the merging of structure and building material. The frame and the envelope have merged and become one building element. Here, a rational and efficient mechanism also functions as the aesthetic form within architecture. It could be imagined that this would be the ideal condition for Semper's textile architecture. Not only would the supporting structure be visually hidden, it would be assimilated into the actual substance of the textile, disappearing completely.

The concave and convex surfaces of this double weave prototype resemble surface-active constructions. The black mohair yarn is stiff, attempting to escape its confines whereas the white, elastic crepe wool pulls together at the middle. Their combined states of tension create an undulating surface.

5 Wood Surfaces and Canvas Weave

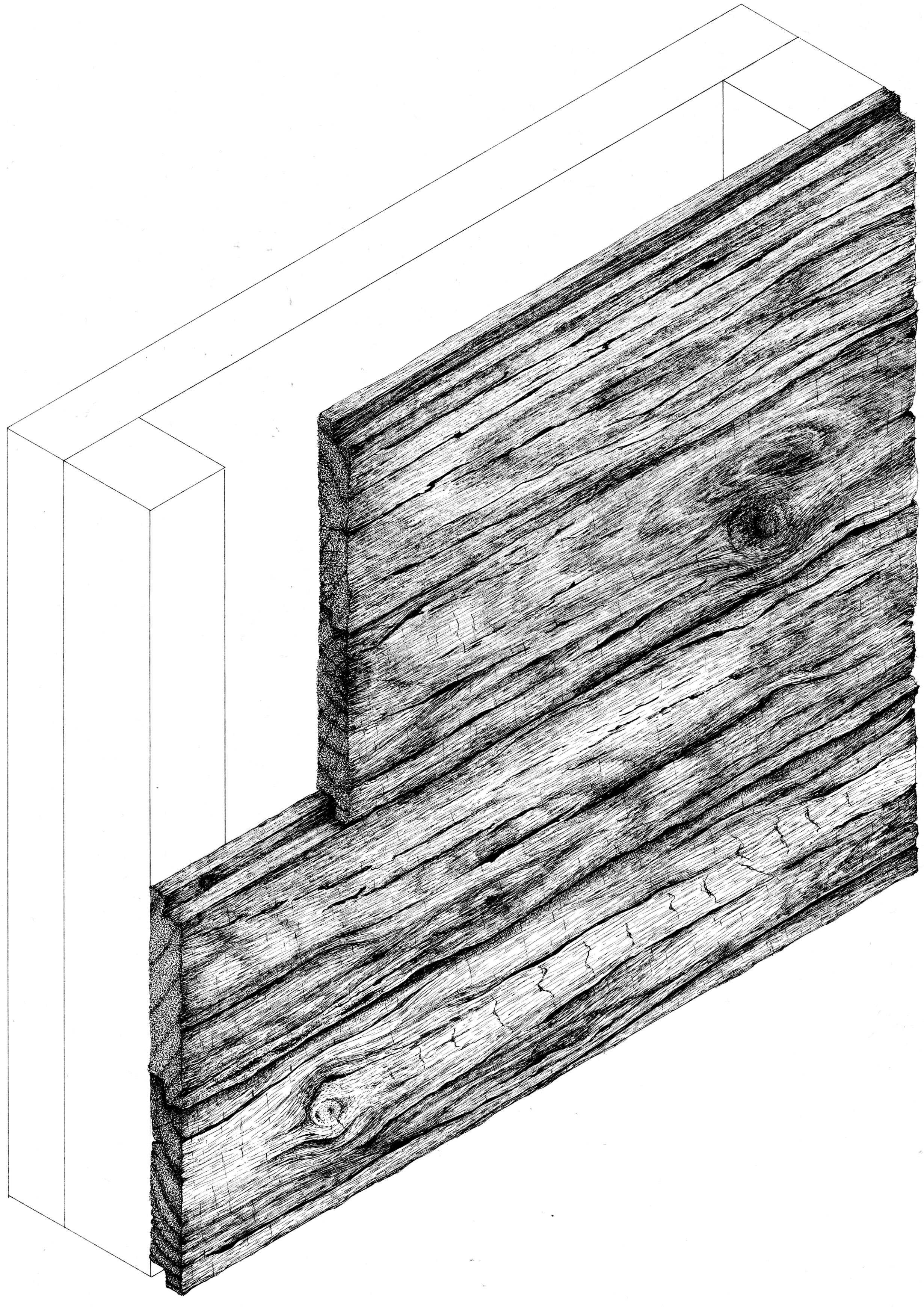
5.1

Introduction

Wood as a material is often appreciated for properties such as its texture, scent and varied surface appearance. Undoubtedly, this material appeals to the senses, but in this thesis the focus will be on wood's structural properties as a material.

In recent years, wood has experienced a return among architects and designers. Moving out of the realm of vernacular architecture and skeleton frame housing, the potential of wood in contemporary architecture is being investigated more actively. Despite advances in the field, experimentation with new structural solutions must take into account the specific nature or *micro structure* of the material.

Within the context of weaving, it is also necessary to consider the compatibility of structure with a chosen material. In this next textile example, there is a clear dialogue between the yarn material and the structure of the weave. This subject area is extremely wide and this one textile prototype represents only a fraction of the whole.



5.2

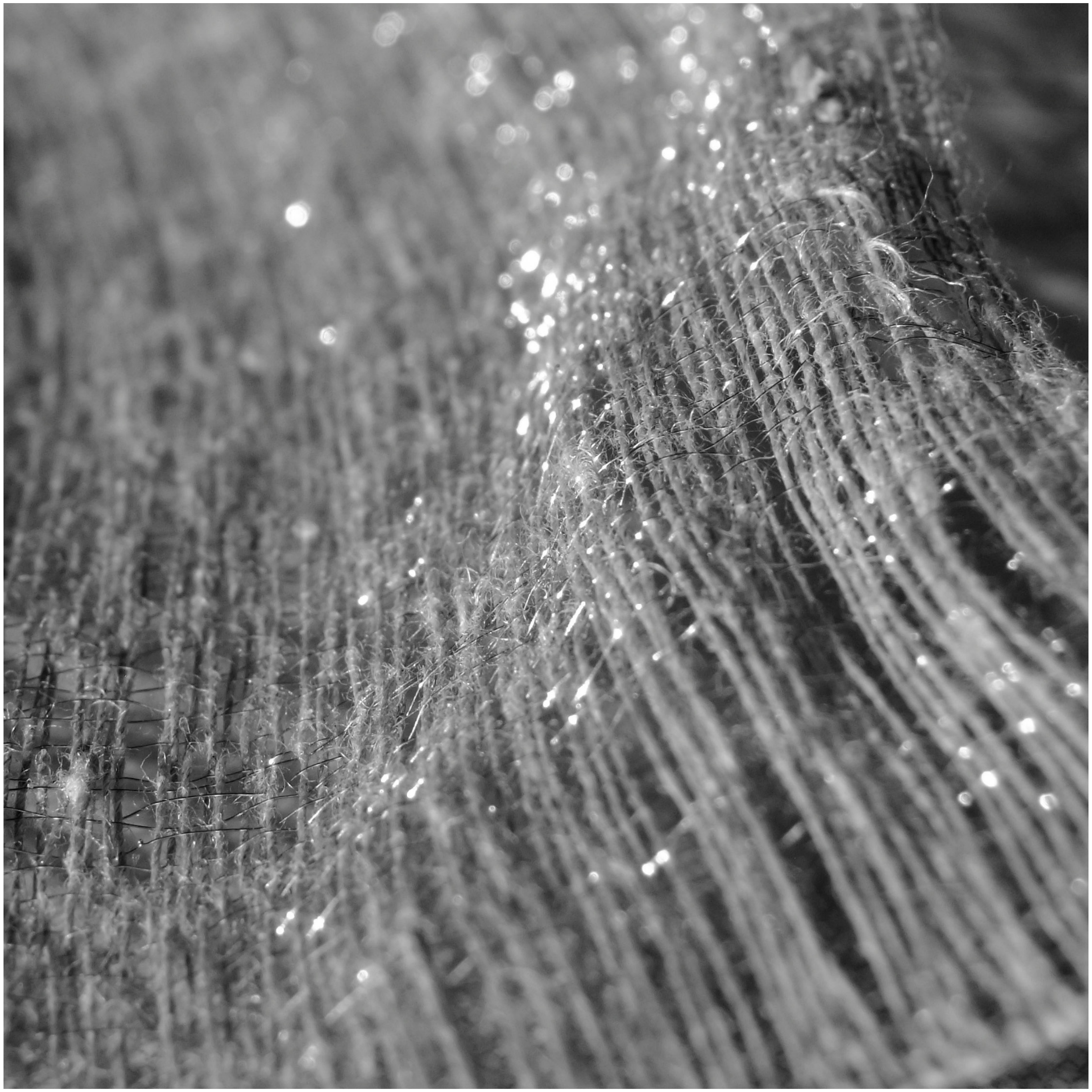
Wood surfaces: Analysis of the fundamental principles of material organization

All wooden surfaces are excellent examples of pattern through internal structure and this becomes particularly apparent upon aging. The aging of wood is often the result of human inhabitation, changes in temperature or humidity, applied physical forces and weathering. By revealing the patterns of usage on its surface, timber and wood are in direct dialogue with their surroundings.

'Moreover, because wood shrinks and swells across the grain, but remains quiescent along the grain, log cabin structures must obey certain rules, the same ones that apply to the making of solid wood furniture: the constructions must always allow movement of the wood across the grain.' (Zumthor 2006, 11). This is an excerpt of architect Peter Zumthor's thoughts on the nature of wooden structures in a project, which investigates new rules of structure and composition for wooden architecture.

The aging of timber is essentially the breakdown or alteration of its original structure due to tension in the material. The fibers in a wooden board become detached from each other causing slits, crevices and holes on the surface as well as on the inside of the board. The distribution of the crevices can appear to be at steady intervals, but nonetheless the structural tensions are random. In its textile equivalent, this structural tension is visible as the crevices in the surface of the fabric. Unlike a weathered wooden board though, the distribution of these voids can be predetermined by the structure of the fabric.

The intrinsic liveliness of wood must be accommodated for within the overall structure. For instance, due to the mobile nature of wood, it is not possible to connect wooden elements directly to the more rigid parts of a construction. These more immobile elements must be designed to respond to the movement of the wood with time. This feature distinguishes wood from other materials. To an extent, the nature of this material dictates the structure, whereas the opposite is often true for other construction materials.



5.3

Modified canvas weave: Analysis of the fundamental principles of material organization

Typical canvas weave structures are appreciated for their airiness due to openings created on the surface of the fabric. This weave type has been commonly used to make lightweight clothing and bases for needlepoint. Unlike satin weave structures, the same structure is visible on the front and back. Canvas weave is sometimes seen as belonging to the same category as the lenoweave due to both having relatively open, but stable structures.

Following the same paradigm found in architecture, decorative elements are often derived from structure in textile also. What characterizes this particular textile sample is the effect of the structure on the woven material. The defining feature of canvas weaves in general is the proximity of two opposing weave structures. For example, one weft-faced structure and another warp-faced structure are placed side by side, creating enough tension to cause an opening in between them. The success of this effect depends on the stiffness of the material and the length of the warp and weft floats.

The structure of the textile shown in the photograph is a modified canvas weave. It is constructed of one row of plain weave after each section of canvas weave. Stiff metal yarns are used in the weft and linen yarn for the warp. The canvas weave structure allows the more pliant linen warp yarns to part, whereas the metal acts as a tie-down component.

By placing two opposing weave structures one after the other, a reaction in the linen warp is achieved. The warp yarns pull together as they cross one another from one structure to the next and slide away from each other where the two opposing structures meet abruptly. This causes the material surface of the fabric to dissolve into a network of crevices and voids.

In this example, both the material and structure hold equal value in constructing the surface. Moreover, the places on the surface where the linen warp yarns move more freely represent a certain 'organized lack of structure'. These loose areas are opposed to the areas of strict plain weave, where both warp and weft yarns are tied down to form a more homogenous, unbroken surface.

5.4

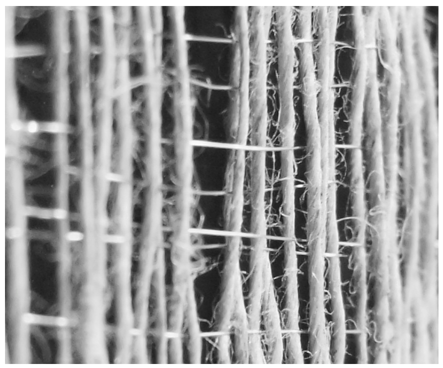
Conclusion: A controlled absence of structure in architecture?

As shown earlier, it is possible and acceptable in weaving to create pattern with crevices and voids such as in canvas weave. By using certain structural systems, a controlled reaction is achieved in the material. Although this is an acknowledged method for creating pattern in textile, this approach is rare in architectural practice. The attempt to control physical forces extrinsic and intrinsic to a material, may even form the basis of architecture's existence. Creating visual effect by allowing materials to react in their most natural way sounds intriguing, yet perilous to the inhabitants of a building.

In the textile piece chosen for this example, the filaments of the linen warp are unruly enough to escape the rigid structure if they are not physically held in place. Here, the thin metal weft yarn acts as a structural tie-down component whereas the linen warp yarns are allowed to 'react' to the structure more naturally. The metal weft has minimal visual and textural effect owing to its thinness. In certain lighting conditions, the metal weft is invisible and only the undulating warp yarns remain visible.

Structural imperfections are often visible on a smaller scale in building materials, where they are accepted and even seen as adding aesthetic quality to architectural surfaces. The method of production or natural growth patterns can leave visible marks on the surface, which can eventually cause cracks or tears in the material.

Architectural materials, whose internal structure has intentionally been left open to change are common. Examples include weathered metals such as copper or steel, exposed wooden surfaces and masonry walls as support for plant life. The material is no longer intact yet it is not seen as violating the structural integrity of the entire building. In what ways could these small-scale structural reactions in material be taken further? Could they perhaps be realized to a wider extent or on a larger scale? Is the current degree of control exercised on building materials always necessary?



A close-up of the interaction between the linen warp yarns and the steel weft

6 Lacunae and Waffle Weave

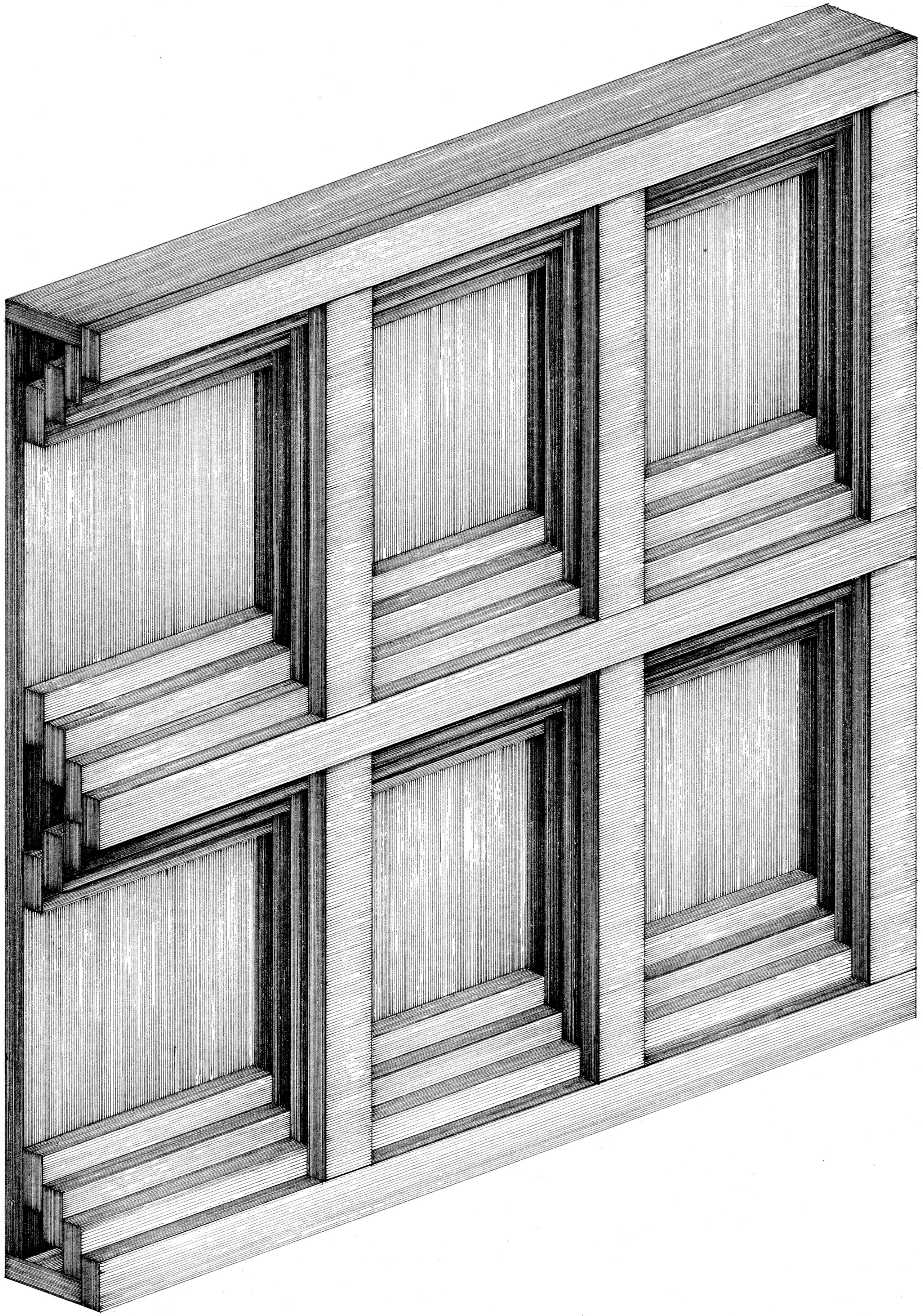
6.1

Introduction

In contrast to the other examples in Part II of the thesis, lacunar surfaces, which are also called coffered surfaces, are more commonly found in historical examples of architecture. In most instances, they are used to clad interior surfaces instead of the exterior of buildings. This type of surface is commonly found on ceilings, but similar structures have been applied to walls also.

A typical lacunar surface is formed from a series of units consisting of stepped boxes that deepen towards the middle. Usually there are many of these single units along one surface, producing an ordered, grid-like effect and adding depth to an otherwise flat plane. Their persistent use throughout history could be attributed to the possibility of achieving ornament through structure.

When viewed from above, the waffle weave may resemble lacunar surfaces visually, but it is the underlying structural principles that are also shared.



6.2

Lacunae: Analysis of the fundamental principles of material organization

One of the most famous examples of lacunae can be found in Rome, on the inside of the Pantheon dome. Due to its repetitive and clean form, lacunae were also a favorite design element of the Viennese architect Adolf Loos. An example can be found in the Kärntner Bar in Vienna, where the lacunae are constructed out of marble. A picture of this ceiling can be seen in figure 10 on page 21 of Part I.

It is somewhat unusual to construct such a ceiling out of marble, with wood often being the material of choice due to its lighter weight. The choice of the material and structure is justified though, since the visual and also physical heaviness of the veined marble is effectively moderated by the stepped and segmented surface.

Lacunar surfaces are significant within the context of this thesis because they are decorative and structural simultaneously. This is also the underlying principle in waffle weave, which will be examined in the next section. The distinctive decorative appearance is the result of a specific way to structurally organize material.

The entire system is organized around an encasing framework for the single square units and within each segment exists the stepped linear members forming the actual lacunae.

6.3

Waffle weave: Analysis of the fundamental principles of material organization

Known for its absorbent qualities, the waffle weave is traditionally found in towels and other household textiles. It derives it name from the geometrical pattern created as a result of the weave structure.

The surface of the textile has a characteristic grid-like appearance made up of either small-scale or large squares that deepen towards the middle. Depending on the number and size of warp and weft yarns used to construct a single geometrical unit, the depth and size of one 'waffle' can be quite dramatic. Not only is this type of weave structure efficient in absorbing liquids, but it also absorbs sound effectively due to a large surface area resulting from the deep crevices on the surface.

The textile prototype, exhibiting an exaggerated and large-scale waffle weave, was chosen as a pair with the lacunar surface because they are structurally and as a result, also visually related to each other. The organizational system around which both architectural and textile samples are based is the same. The stacked linear members move closer to one another as they near the center, creating a radial effect. When moving from the inside to the outside of the waffle, the amount of warp yarn used to hold the weft in place diminishes gradually. At the outermost edge, there is only one warp yarn holding the weft in place on each corner of a single waffle. Additionally, the structural function of each yarn holding the surface together is easily apparent, as is the organization of material of on the stepped lacunar surface.

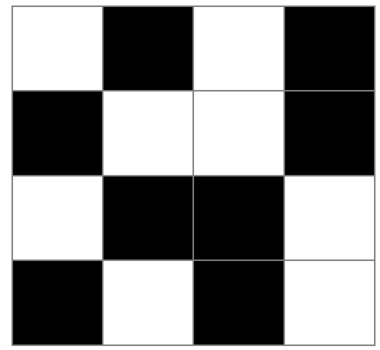
6.4

Conclusion: The grid as a form determining element

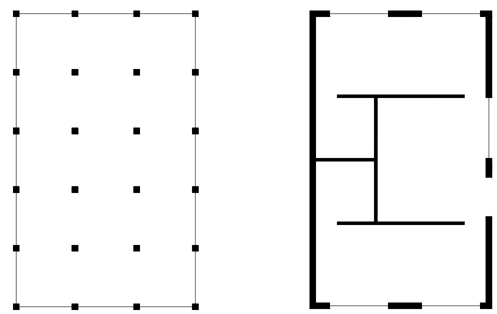
Both architecture and weaving are based largely on grid formations. Lacunar constructions and waffle weave are prime examples of an underlying grid. This may not always be square or regular, but the principles regarding grid formations in both fields are similar. Its most defining feature is the repetition of one single unit or a set of units in a particular order. Grids are the most efficient way of achieving large spans or surfaces composed of a single repetitive sequence.

The grid is composed of linear elements and the spaces in between them, making it distinctly a filigree structure. In the case of weaving and architecture, these elements usually follow vertical and horizontal paths.

Grid structures are present in textile and architecture either visibly or invisibly. From some surfaces it is possible to discern the underlying structure, as with lacunar ceilings and waffle weaves. These examples take the idea of exposed structure further though. Following a modernist paradigm of truth in structure and material, both examples derive aesthetic benefit from their material and method of construction.



An image of a weave. In weaving, the structure of the fabric can be read from this binary representation.



A large degree of information regarding the structure of a building can be read from its floor plan. Above are two examples of structural orgnization in architecture.

Endnote

The woven samples cover a range of different structures and the materials used vary greatly also. Manmade fibers as well as natural materials were used, depending on their intended purpose in the prototype. These textiles have been produced as part of the research into woven structures and therefore are not intended as fully functional samples of textile. In these prototypes, the focus is on the various possibilities of organizing yarns and fibers, instead of aesthetic and functional aspects.

The architectural drawings are hand drawn in ink, using isometric projection, in most cases with a thirty-degree angle. Two drawings are drawn using a twenty-degree angle to avoid perspective distortion. This style of drawing is commonly used to produce scale drawings and allows measurements to be taken directly from the drawing if needed. The scales of the drawings range from 1:5 to 1:20, depending on what part of a particular structure the focus is directed at. The dimensions of the elements in each structure follow real life examples as closely as possible.

All pictures and textile structures depicted in Part II have been made specifically for the purposes of this thesis by the author. References made in the text are from books found in the bibliography of Part I.